Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

FEBRUARY, 1953

TABLE OF CONTENTS, Page 59

RARY
953
DETROIT

Ohio Rolls

SHAPING METAL FOR ALL INDUSTRY

STEPPED-UP PRODUCTION

Greatly-enlarged plant facilities at Lima mean more Ohio Rolls to enhance your production. Choose from 11 types of Ohio Iron and Steel Rolls:

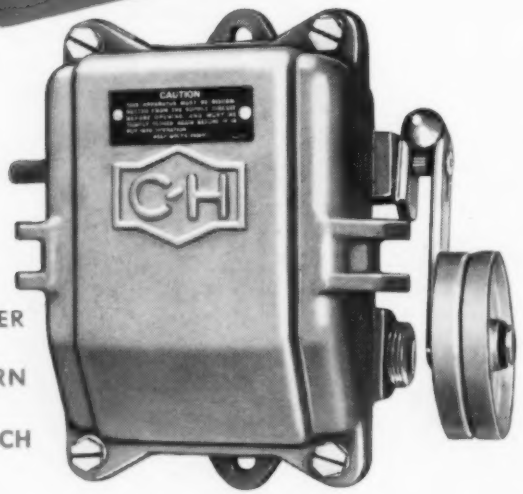
Carbon Steel Rolls
Ohioloy Rolls
Ohioloy "K" Rolls
Holl-O-Cast Rolls
Chilled Iron Rolls
Denso Iron Rolls
Nickel Grain Rolls
Special Iron Rolls
Nioloy Rolls
Flintuff Rolls
Ohio Double-Pour Rolls

THE OHIO STEEL FOUNDRY CO

LIMA, OHIO • PLANTS AT LIMA AND SPRINGFIELD, OHIO

new CUTLER-HAMMER TRACK TYPE limit switches

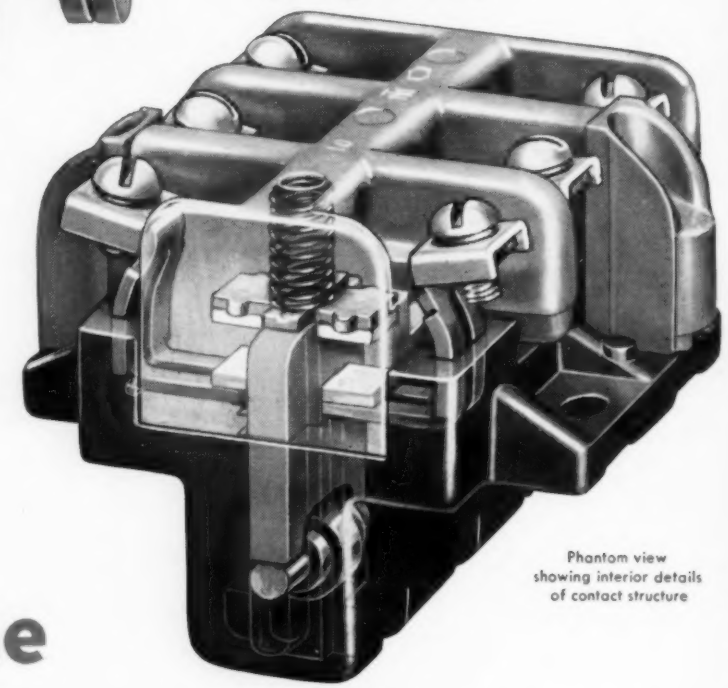
(Bulletin 14977)



ROLLER LEVER SPRING RETURN SWITCH

FORK LEVER TWO POSITION SWITCH

Clamp-on type operating lever can be mounted at any angle on shaft. Also can be readily shifted to opposite end of shaft for right or left hand track installation. Overtravel provided in both directions. Cast iron NEMA 1 Standard, NEMA 4 Watertight or NEMA 5 Dusttight enclosures. Tapped for conduits. Contacts rated at 1.25 amps. at 250 volts d.c. Two pole or three pole with contacts normally open and/or normally closed, with or without overlap.



Phantom view showing interior details of contact structure

utilizing the all new simplified contact structure

STANDARDIZED . . . the identical contact structure used in many other Cutler-Hammer limit switches, mill accessory masters, foot switches, etc. It is *completely* interchangeable . . . simplifies spare parts and replacement problem.

SIMPLIFIED . . . this contact structure is reduced to simplest elements, for easy understanding, for easy accessibility, for easy parts renewal.

STURDY . . . cam and roller actuated, long-lived, dependable. Small and compact. Many features, special alloy tips, arc-resistant molded supports, twin break contacts, etc., etc., etc. CUTLER-HAMMER, Inc., 1269 St. Paul Ave., Milwaukee 1, Wis. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto.

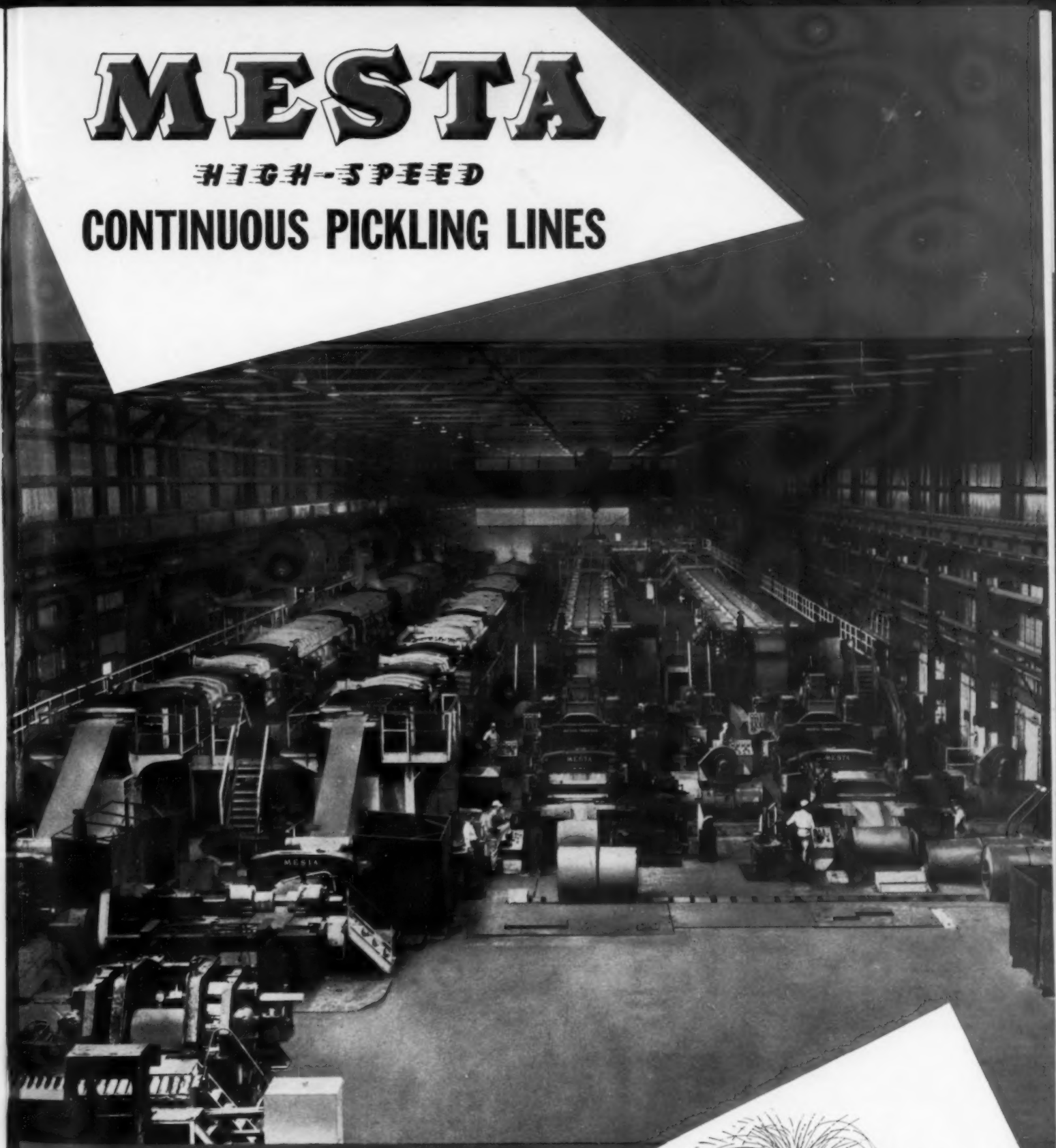
CUTLER-HAMMER
MOTOR CONTROL
C-H

IRON AND STEEL ENGINEER: published monthly by Association of Iron and Steel Engineers, 1010 Empire Bldg., entered as second class matter January 25, 1924 at Pittsburgh, Pennsylvania, under Act of Congress, March 3, 1879. $7.50 per year in United States and Canada, $10.00 foreign countries. Volume 30, No. 2.

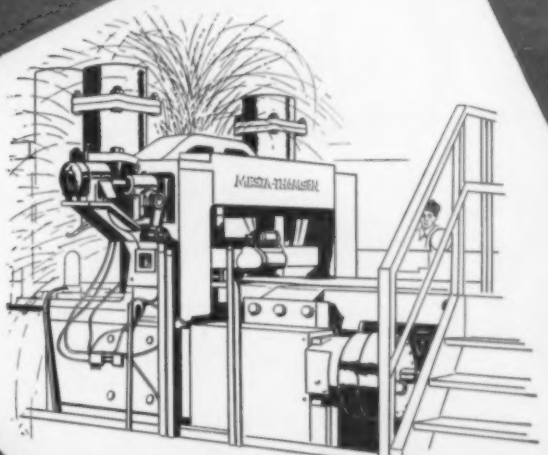
MESTA

HIGH-SPEED

CONTINUOUS PICKLING LINES



BATTERY OF FOUR MESTA HIGH-SPEED CONTINUOUS PICKLING LINES WITH TRIMMERS, UPCOILERS, AND MESTA-THOMSON FLASH WELDERS



MESTA-THOMSON FLASH WELDER INSTALLED IN A MESTA HIGH-SPEED CONTINUOUS PICKLING LINE

Designers and Builders of Complete Steel Plants

MESTA MACHINE COMPANY

PITTSBURGH, PENNSYLVANIA

Tapping a Heat

A GOOD MIXER

The skilled National Roll metallurgist mixes his batch according to formula, but he also knows through experience the extra ingredients to add to control roll strength, hardness or heat-resistance . . . and when the heat is tapped, it is a certainty that the batch is *right* to produce the roll specified. • Careful attention to a multitude of details in every step in roll making here at National results in sound, long wearing iron and alloy iron rolls that will live up to your service expectations.

NATIONAL ROLL

National Rolls

THE NATIONAL ROLL & FOUNDRY CO.

AVONMORE, PENNSYLVANIA

SPECIALISTS IN IRON AND ALLOY IRON ROLLS AND CASTINGS

KEEP 'EM ROLLING with TEXACO REGAL OIL

HERE'S HOW: The oil film bearings of your back-up rolls will do a better job for you, and cost you less for maintenance when they're protected with *Texaco Regal Oil*. This turbine-quality oil stands up under heavy loads and high temperatures.

Texaco Regal Oil resists oxidation, emulsification and sludging. It keeps the oil lines clear, permitting clean, cooling lubricant to flow constantly to the bearings. Your bearings last longer. Your costs come down. There is a complete line of *Texaco Regal Oils* to meet your exact requirements.

Over on the drive side, the best protection for enclosed reduction gears is *Texaco Meropa Lubricant*. Its high and lasting EP properties assure longer gear life and lower maintenance costs.

Talk to a Texaco Lubrication Engineer. He can help you "keep 'em rolling." Just call the nearest of the more than 2,000 Texaco Distributing Plants in the 48 States, or write The Texas Company, 135 East 42nd Street, New York 17, N. Y.

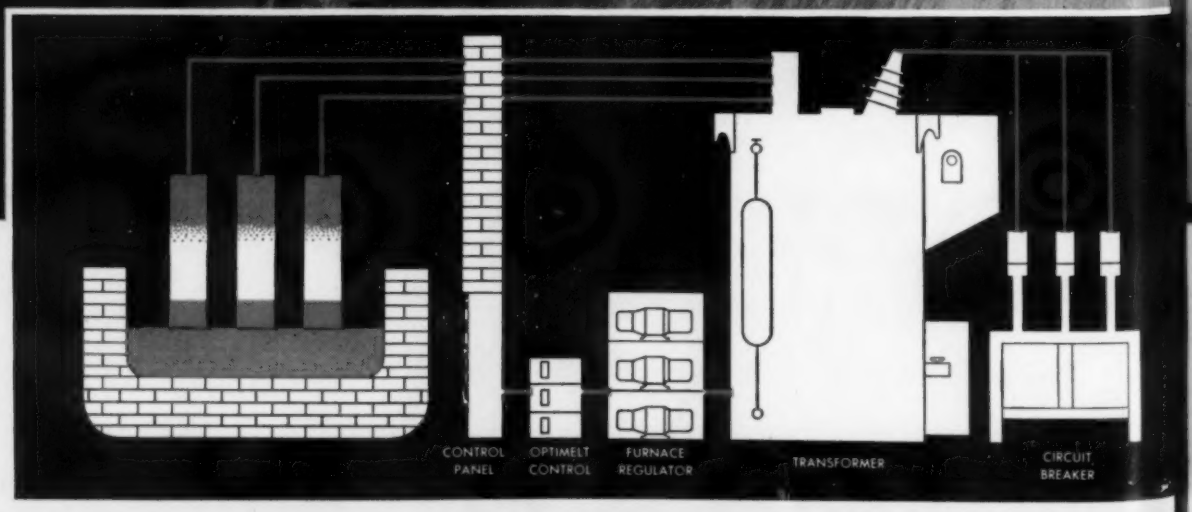
TEXACO

TEXACO Regal Oils

(HEAVY CIRCULATING OILS)

TUNE IN . . . TEXACO STAR THEATER starring MILTON BERLE, on television Tuesday nights. METROPOLITAN OPERA radio broadcasts Saturday afternoons.

They did what you can do to produce more



One of steel's toughest electrical problems is solved this way:

Arc furnaces give electrical apparatus one of its toughest assignments. They slam dead shorts across transformers. They rip open circuit breakers 30 to 100 times a day. And they demand ultra reliability because a power failure can be disastrous.

In the midst of violence: precise regulation

Yet in the midst of this violence they also demand *precise electrical regulation* because power is a major cost item and how it is used vitally affects production rates. For these special requirements, Westinghouse has produced special equipment. Today, more Westinghouse furnace equipment is in use than all other makes combined.

Radically designed transformers and breakers

When the furnace electrode touches the charge, a tremendous power surge tries to rip the transformer apart. So Westinghouse supplies its radical *shell-form* transformer which is far stronger than the conventional construction. Similarly Westinghouse supplies special compressed-air circuit breakers which operate seven times longer between maintenance periods than ordinary breakers.

Furnace is regulated by electrical brains

The real trick in running the furnace is maintaining desired power input. Rototrol® does this by watching furnace conditions and continuously adjusting electrode height. But the ultimate refinement is the Westinghouse Optimelt® control which automatically determines the best kw input (according to furnace conditions) and then directs the Rototrol to hold it there.

Call Westinghouse early on EVERY project

This equipment is a good example of the engineering that Westinghouse applies to steel mill problems. When *your* next project comes up, call Westinghouse early in the planning stage.

FREE BOOK ON ARC FURNACES

This 20-page booklet tells how modern Westinghouse equipment can improve your operations and cut costs. Write for B-4695 "Westinghouse Equipment for Arc Furnaces"—Westinghouse Electric Corp., Box 868, Pittsburgh 30, Pa.

YOU CAN BE SURE...IF IT'S
Westinghouse

EQUIPMENT FOR
STEEL PRODUCTION

NO "DRESS REHEARSALS"
with
NATIONAL
TRADE-MARK
Carbon Brushes
for
Main Drive Motors and Generators

● "National" carbon brushes come to you time-tested for top performance all through the mill. And in big-time applications, like main drive motors and generators, this *finer quality* really pays off — may, in fact, become a vital factor in upholding full production.

● The more generally used grades and sizes of "National" carbon brushes for toe-to-toe and tandem-type holders have been *standardized* — a practice pioneered by NATIONAL CARBON to help concentrate research, development and manufacturing facilities *where they mean the most to you.*

● *Standardized* brushes are mass-produced under careful quality control. Always in stock for immediate delivery, they sell for the same low unit price regardless of quantity. Investigate these standardized brushes for *your* equipment before placing your next order.

NATIONAL STANDARDIZED BRUSHES

BETTER— PRODUCT—PACKAGE—PRICE— FASTER

The term "National" is a registered trade-mark of Union Carbide and Carbon Corporation

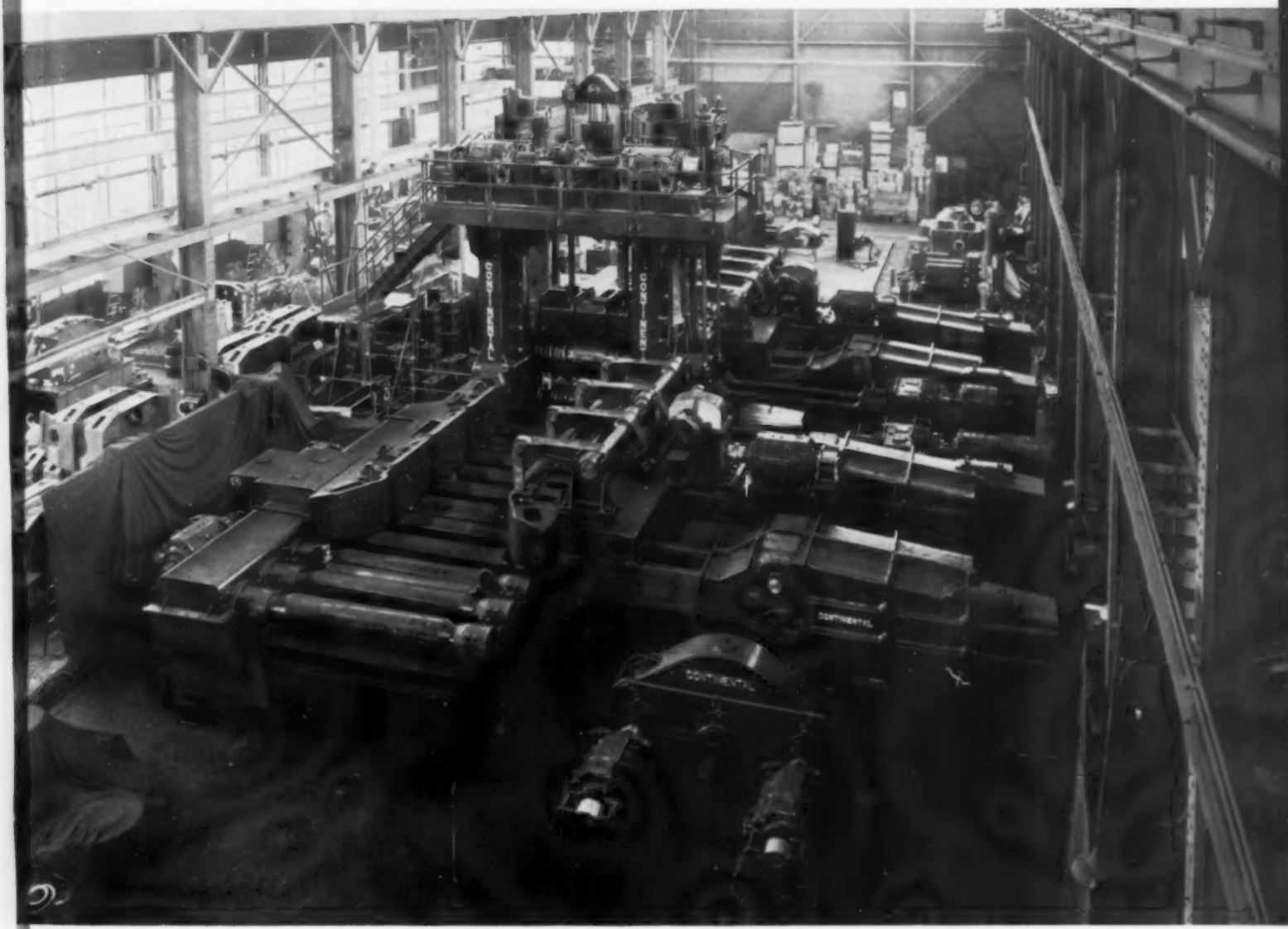
NATIONAL CARBON COMPANY
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street, New York 17, New York

District Sales Offices:
Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

In Canada:
NATIONAL CARBON LIMITED
Montreal, Toronto, Winnipeg

CONTINENTAL

SHOP ASSEMBLY OF A 40" BLOOMING MILL WITH TABLES AND MANIPULATOR AT WHEELING PLANT



Complete Rolling Mill Installations

SLABBING MILLS	Mills complete with Auxiliary Equipment	BLOOMING MILLS
UNIVERSAL MILLS		STRUCTURAL MILLS
PLATE MILLS	★ ★ ★	RAIL MILLS
HOT STRIP MILLS	CONTINENTAL CHIPPER	BILLET MILLS
COLD STRIP MILLS	ROLL LATHES	ROD MILLS
TEMPER MILLS	SPECIAL MACHINERY	MERCHANT MILLS

CASTINGS—carbon and alloy steel from 20 to 250,000 pounds

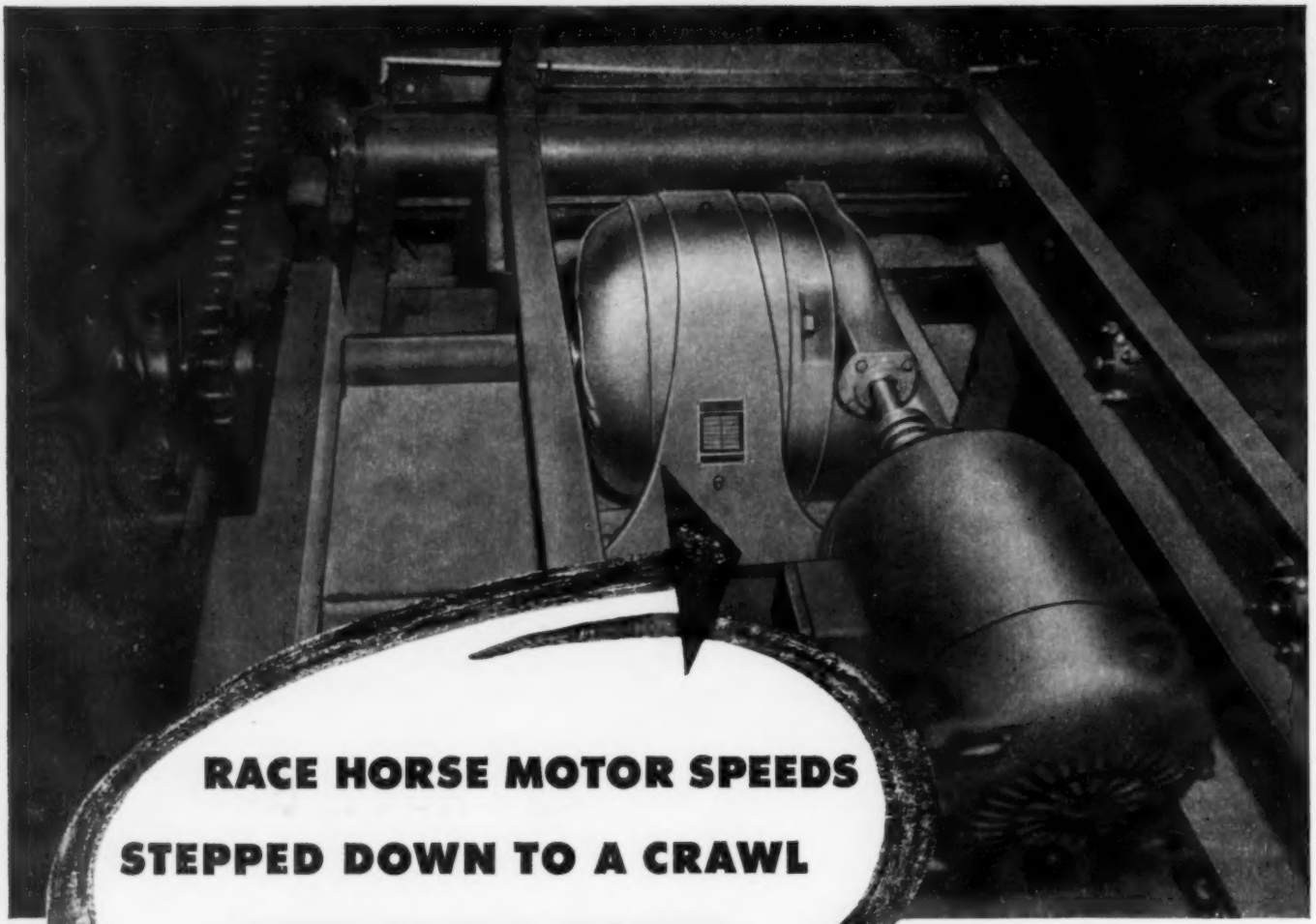
ROLLS—iron, alloy iron and steel rolls for all types of rolling mills

WELDMENTS—fabricated steel plate, or cast-weld design.

Plants at
East Chicago, Ind. • Wheeling, W. Va. • Pittsburgh, Pa.

CHICAGO • PITTSBURGH

CONTINENTAL
Foundry & Machine
Company



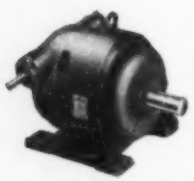
RACE HORSE MOTOR SPEEDS STEPPED DOWN TO A CRAWL WITH LINE-O-POWER

24WL Right angle Line-O-Power Drive on a Chain Conveyor

Double reduction straight line drive

Triple reduction straight line drive

Double reduction vertical drive



Double reduction right angle drive

FOOTE BROS.

Better Power Transmission Through Better Gears

FOOTE BROS. GEAR AND MACHINE CORPORATION
4545 South Western Boulevard • Chicago 9, Illinois

On conveyors or other materials-handling equipment, slow speed is essential. With Line-O-Power Drives, it is possible to transform high motor speeds into almost any desired slow end speed.

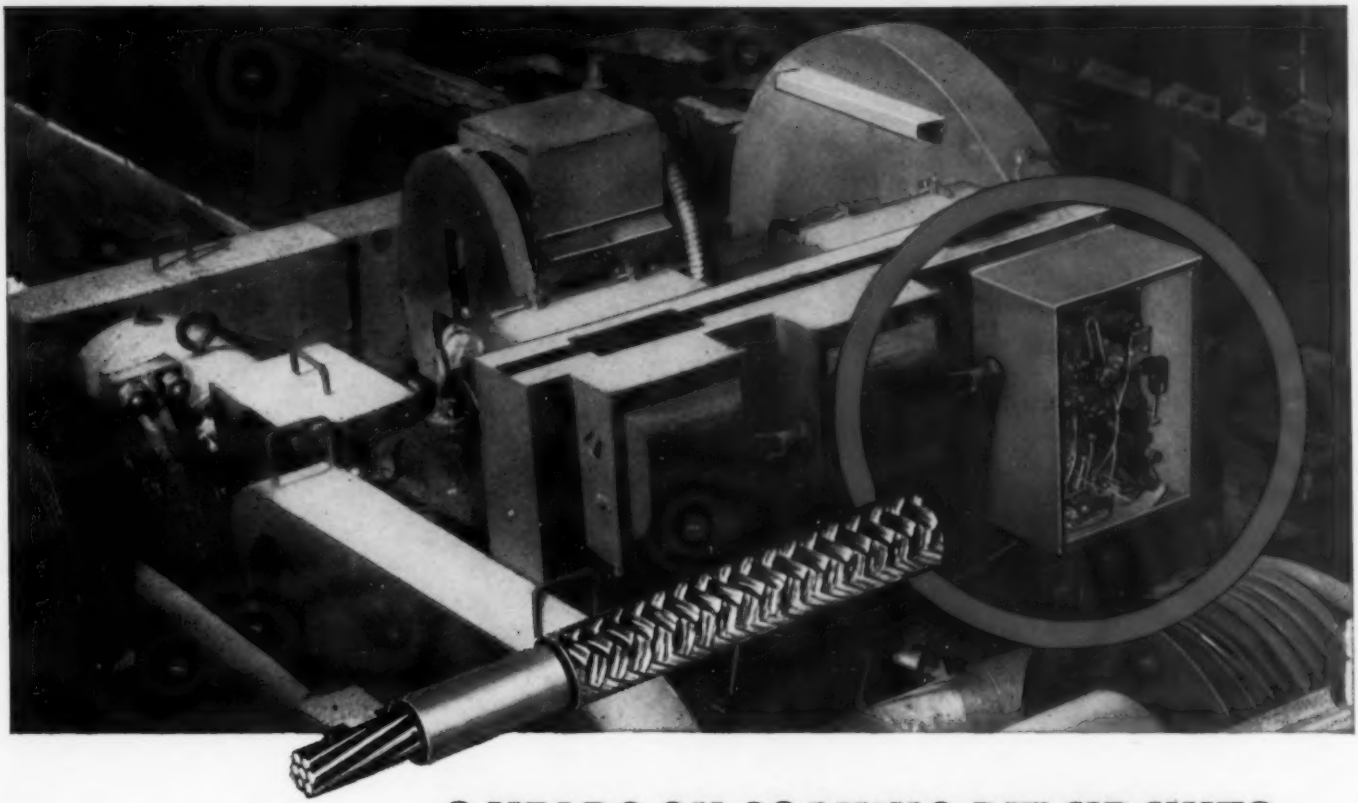
Here, for example, is a compact Line-O-Power Drive on a chain conveyor. Low in original cost, it provides economical service day in and day out with minimum attention. These drives have proved their value to industry because of their compact size, sturdy construction and high efficiency.

First reduction is taken through precision worm gearing, second and third reductions through Duti-Rated helical gearing. Duti-Rated Gears have file-hard tooth surfaces with ductile cores that permit heavy loading and yet assure long life. Available for straight line service — for right angle service — or for vertical application.

FOOTE BROS. GEAR AND MACHINE CORPORATION
Dept. IAS, 4545 South Western Boulevard, Chicago 9, Illinois

Please send me Bulletin LPB on Line-O-Power Drive.
I am interested in
☐ Straight line drive ☐ Vertical drive ☐ Right angle drive

Name.....
Company.....
Position.....
Address.....
City..... Zone..... State.....



2 YEARS ON SOAKING PIT CIRCUITS

and still like new:

OKOTHERM CONTROL WIRE

With a pit temperature of 2400° and an ambient temperature way in excess of 300° F, the soaking pit shown above is an extremely tough test of control wiring.

Before using Okotherm, this steel mill equipped its soaking pits with asbestos insulated control wire. This wire, however, lasted an average of only two months. Replacing the asbestos wiring circuits meant that the pit had to be shut down; this involved cooling and reheating periods for each pit. Obviously, production was interrupted every two months or so, with considerable material, repair and maintenance costs also involved.

In September 1950, Okotherm cable was installed. *Since that time, no replacement has been necessary.* As of October 1952 the Okotherm cable is still in excellent condition!

Okotherm insulation, a silicone rubber compound developed by Okonite, maintains excellent electrical and physical properties over an extremely wide temperature range. High moisture resistance is another Okotherm characteristic. From printing presses to jet engines, Okotherm has successfully replaced other types of heat-resisting wires with overall savings as high as 88%.

Soaking pit circuits are only one of its many steel mill uses when high temperatures present a problem. Why not ask your Okonite representative about Okotherm insulation today? The Okonite Company, Passaic, N.J.

The best cable is your best policy

OKONITE SINCE 1878 *insulated wires and cables*

1408

Another large synchronous motor by ELLIOTT

● The stator is over eighteen feet high—and yet the air gap between rotor and stator in this huge motor is held to one-eighth inch! That's precision manufacture, as applied in Elliott-built electrical equipment, with all dimensions tailored to a real fit by Elliott "Fabri-Steel" welding technique.

This particular motor is destined for driving the main rolling mill at a big tube mill. It has 294 stator coils, 112 poles, is rated 2000 hp, 64 rpm and develops a pull-out torque of 570,500 lb-ft.

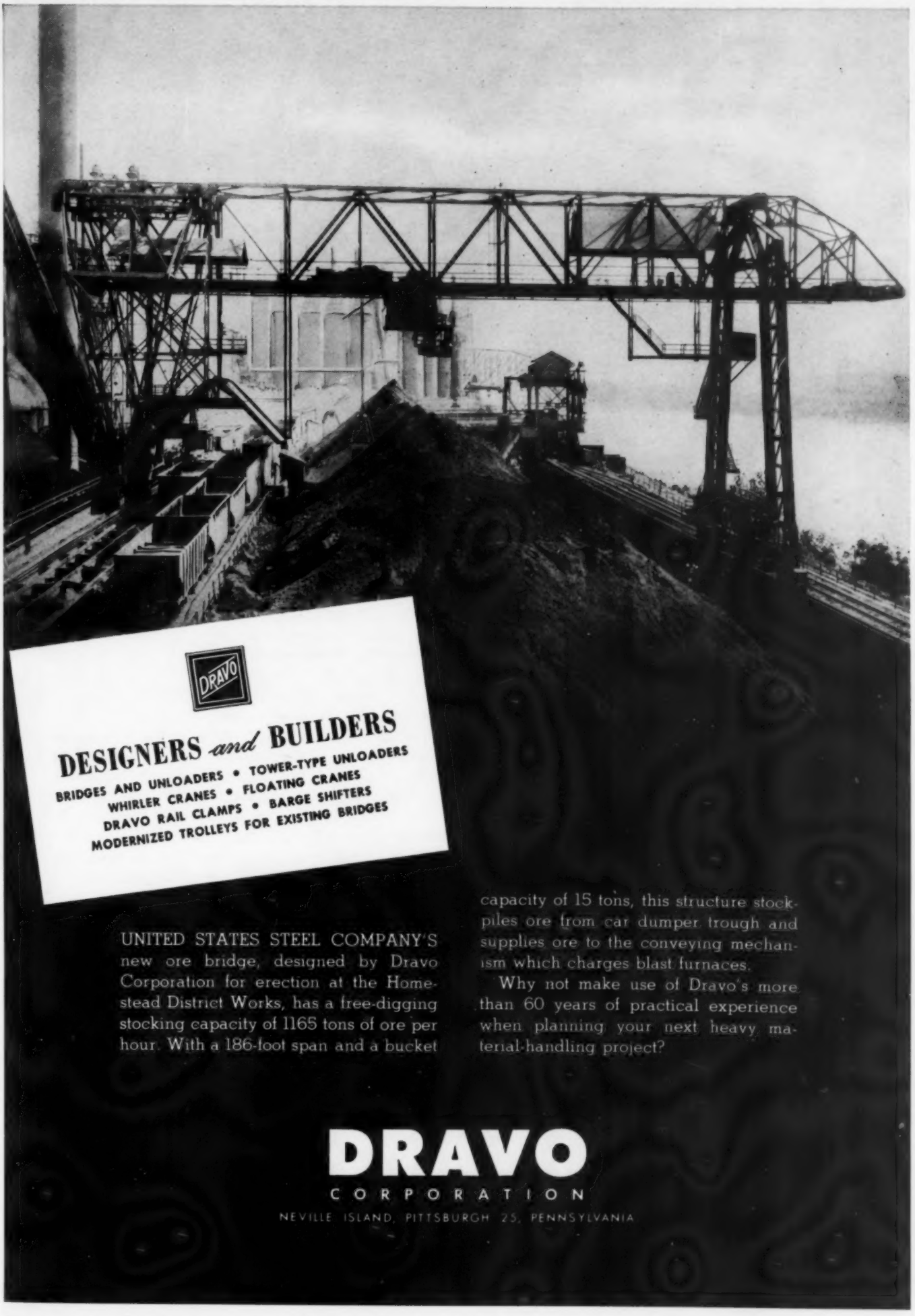
Big motors like this are an Elliott specialty. Why not check?

ELLIOTT Company

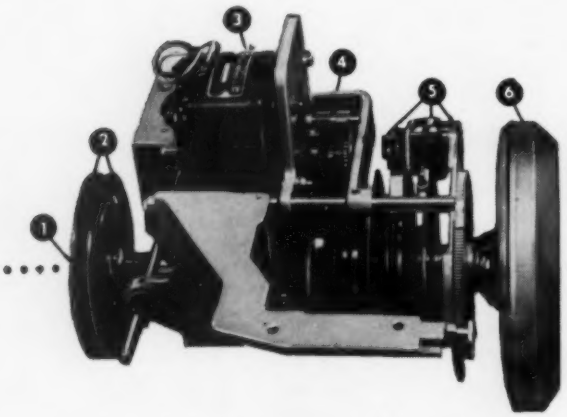
Ridgway Division
RIDGWAY, PA.

Plants at: JEANNETTE, PA. • RIDGWAY, PA.
AMPERE, N. J. • SPRINGFIELD, O. • NEWARK, N. J.
DISTRICT OFFICES IN PRINCIPAL CITIES

R2-13


DRAVO
DESIGNERS and BUILDERS
BRIDGES AND UNLOADERS • TOWER-TYPE UNLOADERS
WHIRLER CRANES • FLOATING CRANES
DRAVO RAIL CLAMPS • BARGE SHIFTERS
MODERNIZED TROLLEYS FOR EXISTING BRIDGES
UNITED STATES STEEL COMPANY'S new ore bridge, designed by Dravo Corporation for erection at the Homestead District Works, has a free-digging stocking capacity of 1165 tons of ore per hour. With a 186-foot span and a bucket capacity of 15 tons, this structure stockpiles ore from car dumper trough and supplies ore to the conveying mechanism which charges blast furnaces.
Why not make use of Dravo's more than 60 years of practical experience when planning your next heavy material-handling project?
DRAVO
CORPORATION
NEVILLE ISLAND, PITTSBURGH 25, PENNSYLVANIA

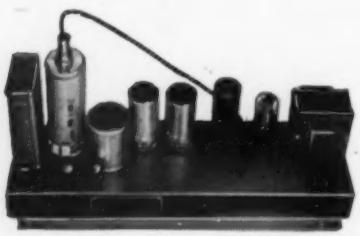
1. Center line of slidewire and shaft
2. Control cams
3. Balancing motor
4. Spring-loaded no-backlash drive
5. Control slidewires
6. Measuring slidewire



POWER IS PERFORMANCE

... and Speedomax Instruments lead with "huge" 12-watt balancing motors!

This partially dis-assembled view of Speedomax shows its two-phase Balancing Motor and gears, with a typically "heavy" load of slidewires and contacting cams for signal and control devices. Several more cams, etc., can be added if necessary; only practical limit is physical space on shaft. Smoothness in operating many contacts is an outstanding Speedomax ability.



Amplifier which feeds the Speedomax balancing motor the controlling half of its power. Torque gradient is especially high where needed most—around balance point—for prompt, positive balancing. This Amplifier leads its field by large margins in sensitivity and in power output.

Good circuit engineering shows in this Slidewire's non-inductive wiring and in the absence of any flexible leads which might form inductive loops.

• Power underlies good performance, in instruments as in automobiles, machine tools or rolling mills. That's why L&N engineers insist that an automatic instrument should operate as positively and promptly as any other high-grade machine.

Even the first null balance potentiometer Recorder we built, back in 1911, which went to a steel mill, had a 110-volt motor instead of a spring drive to run its balancing mechanism, chart and signalling contacts. And, while its pioneering of balance-method measurement attracted the most attention, its ample power certainly helped establish L&N Recorders as the coming idea in process Instrumentation.

Power has done the same for Speedomax instruments. Twenty years ago, Speedomax pioneered the electronic idea of measurement—in a husky, powerful piece of equipment. Today's models have from 2 to 4 times more power in their balancing motors than any other current models of electronic controllers, recorders or indicators.

This power means superior performance in both load-carrying and speed. Load-carrying ability applies especially when the motor operates, in addition, an unusual number of contact devices. But even the most usual Speedomax jobs—automatic control, for instance—can call on the instrument's power for high operating speed in handling the normal number of control devices. The strong, wide-faced, rigidly-mounted cams and gears so typical of Speedomax instruments start moving instantly, move rapidly and stop dead still without coast. Signalling and control action is correspondingly crisp and precise.

Speedomax for industrial use is described in Catalog ND46 (1); additional information for unusual applications is given in Technical Publication ND46(1). Either will be sent on request by our nearest office or from 4942 Stenton Ave., Philadelphia 44, Pa.

LEEDS NORTHRUP

instruments automatic controls • furnaces

CAREER OPPORTUNITIES AT L&N

Expansion program of this long-established firm has many features to attract outstanding recent graduates in engineering and science. Opportunities are in sales field engineering, product and application engineering, research, advertising, market development. Widely-respected policies assure recognition of progress and achievement. Address Personnel Manager for preliminary interview at nearest of 17 L&N offices.

Jrl. Ad. ND46(8)

The New Bliss Slitter...

First Choice of Another Major Manufacturer

Rugged design and rigid components are only two of the reasons why one of the nation's top automotive electrical equipment manufacturers chose the new Bliss rotary slitter for coils or sheet stock.

Look at all these features:

1. Square gearing enables slitter knives to vary in diameter, permitting cutters to be ground on the periphery; permits knife clearance adjustment to suit gauges.

2. Center bearing controls deflections of arbor where unusually severe loads are encountered.

3. Vertical adjustment of arbor is simplified by handwheel and jackscrew mechanism.

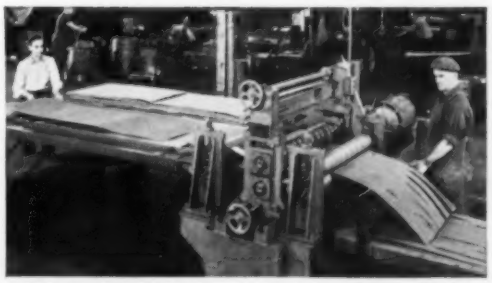
4. Entry and delivery pinch rolls are steel-mounted in anti-friction bearings and spring loaded.

5. Forged steel arbor facilitates alignment of cutter and spacer. Diameters are selected to minimize deflection.

6. Welded steel base is rigidly reinforced to support normal loads. Bliss weldments are thoroughly stress-relieved and shot-blasted.

7. Welded steel housings: Outboard housing is traversed by handwheel and screw mechanism for easy removal of arbors for re-tooling.

8. Gear reduction unit, completely enclosed, has capacity to carry full torque loads.



This 36" Bliss slitter makes cuts from 5/8" to 9-7/16" wide. Material thickness varies from 0.014" to 0.045" lamination steel and sheet insulation. Average speed is 150 fpm.

9. Drive motor, completely enclosed, is available for use with either AC or DC current.

10. Arbor bearings are either anti-friction or plain, depending on the requirements.

Make Your Next Slitter the New Bliss

Bliss offers standard slitters, complete slitting lines and accessories. Bliss slitters are reliable in operation, simple to maintain...a sure way you can save time and money by slitting your own strip. If job requirements vary from standard, Bliss engineers can design to meet your needs. Write for Bulletin 44.

E. W. Bliss Company, General Office: Canton, Ohio

ROLLING MILL DIVISION: SALEM, OHIO

E. W. Bliss (England) Ltd., Derby, England

E. W. Bliss Company (Paris), St. Ouen sur Seine, France

Branch offices in Chicago, Cleveland, Dayton, Detroit, Indianapolis, New Haven, New York, Philadelphia, Rochester, Toledo; and Toronto, Canada. **West Coast Representatives:** Moore Machinery Co., Los Angeles and San Francisco; Star Machinery Co., Seattle. **Other dealers** in United States cities and throughout the world.

Remember: **for Presses, ROLLING MILLS, Special Machinery...** **It's Bliss**

Wagner

Protected Type Motors

solve tough production problems

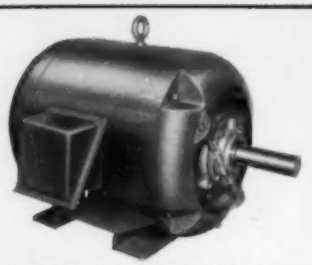
Do you need motors to operate under severe conditions? If you do—you can solve your problem easily with Wagner's complete line of protected type motors.

They are specifically designed for use wherever EXTRA protection is demanded —for bearings or windings . . . against corrosive vapors or abrasive dusts . . . in explosive atmospheres or in exposed outdoor locations.

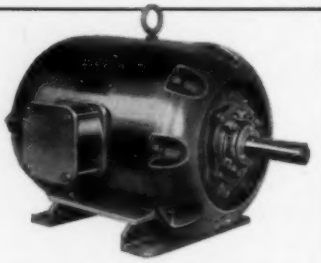
In their specific applications, each of these Wagner Motors assures complete protection of vital parts. Wagner Motors are backed by more than sixty years of motor building experience.

* * *

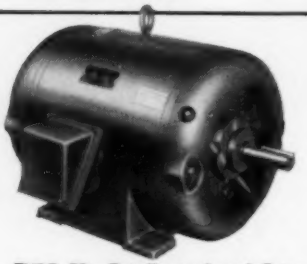
A Wagner engineer will be glad to help you select the correct motor for *your* specific application. Consult the nearest of our 32 branch offices, or write for Bulletin MU-185 for complete information.



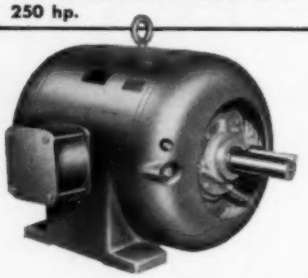
TYPE CP—Totally-enclosed Fan-cooled. Steel frame. 1 to 250 hp.



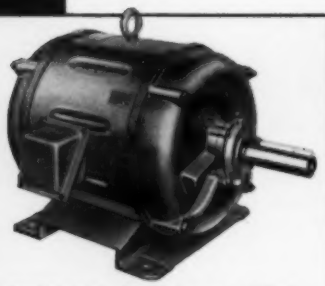
TYPE HP—Explosion-proof. Steel frame. 1 to 250 hp.



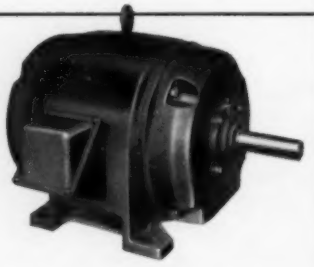
TYPE EP—Totally-enclosed Fan-cooled. Cast iron frame. 2 to 250 hp.



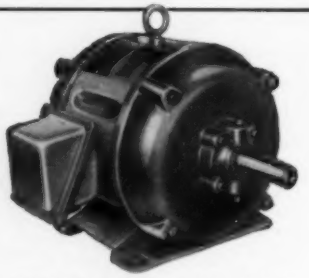
TYPE JP—Explosion-proof. Cast iron frame. 2 to 250 hp.



TYPE RP—Drip-proof. Steel frame. ⅛ to 400 hp.



TYPE XP—Splash-proof. Cast iron frame. ¾ to 200 hp.



TYPE TP—Totally-enclosed, non-ventilated. ¼ to 15 hp.

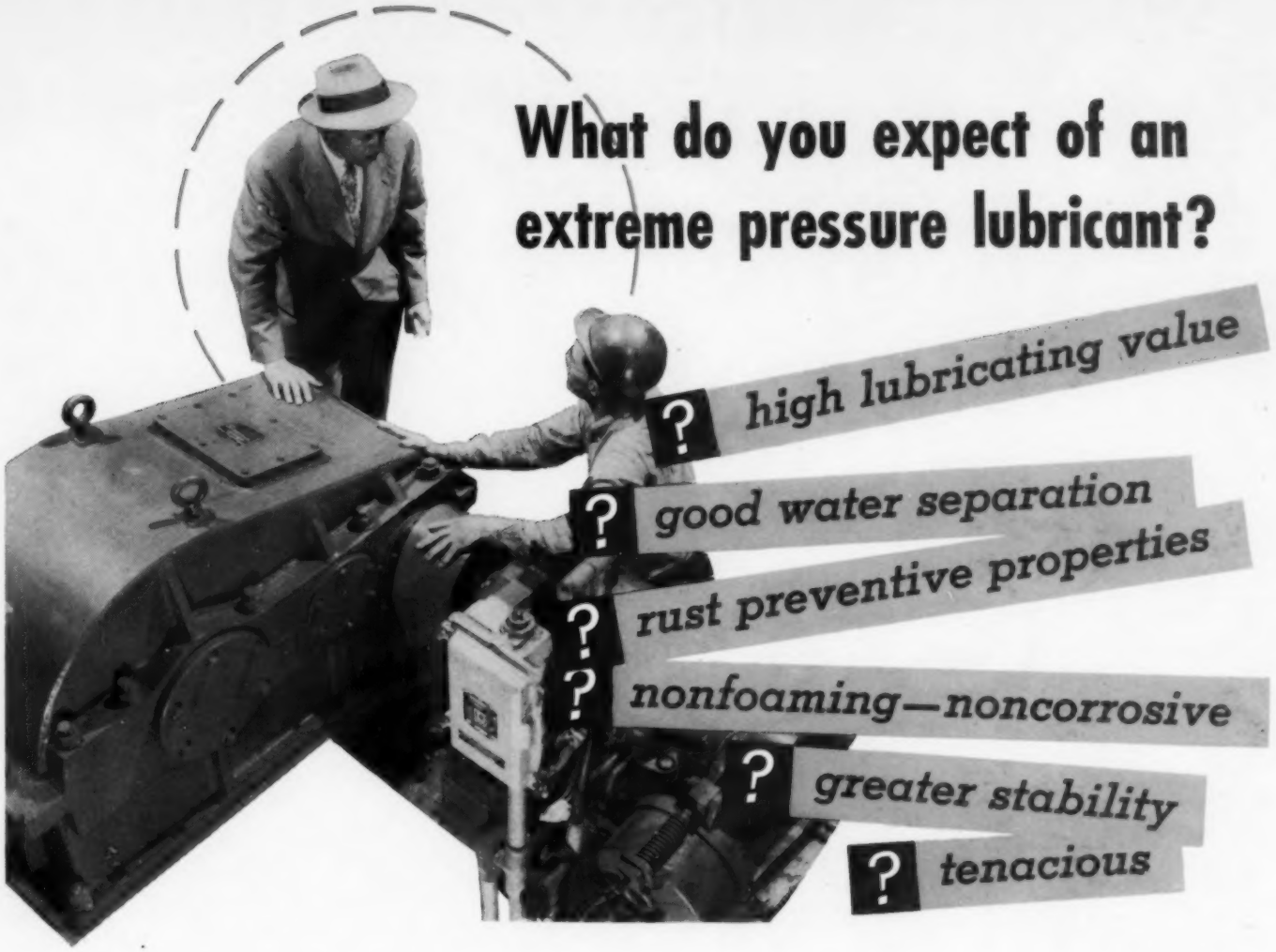
Wagner Electric Corporation
EST. 1891

WAGNER ELECTRIC CORPORATION
6483 Plymouth Ave., St. Louis 14, Mo., U.S.A.

ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES
AUTOMOTIVE BRAKE SYSTEMS—AIR AND HYDRAULIC

BRANCHES IN 32 PRINCIPAL CITIES

M53-10


What do you expect of an extreme pressure lubricant?
? high lubricating value
? good water separation
? rust preventive properties
? nonfoaming—noncorrosive
? greater stability
? tenacious

●You'll get them all with GULF E.P. LUBRICANTS

All the desirable properties of extreme pressure lubricants are combined in Gulf E. P. Lubricants to insure longer gear and bearing life, and lower maintenance costs for steel mill gear drives.

Gulf E. P. Lubricants are specially compounded to withstand the shock loads and high pressures encountered in the toughest service. And they are outstanding in their ability to separate from water. When the proper grade is used and good maintenance practice is employed, lubrication difficulties caused by water can be minimized.

Other advantages: nonfoaming—saves loss of lubricant and mopping up; tenacious—minimizes channeling and throwoff; extremely stable for this type of lubricant; help prevent rust; and they are just as suitable for all types of bearings.

Gulf E. P. Lubricants are available in the proper viscosity for every gear requirement, ranging from 55 to 1050 S.U.V. at 210°F. For specific recommendations for your equipment, call in a Gulf Sales Engineer today. Write, wire, or phone your nearest Gulf office, or send the coupon below.

GULF INDUSTRIAL LUBRICATION

Gulf Oil Corporation · Gulf Refining Company ISE
719 Gulf Building, Pittsburgh 30, Pa.

Please send me, without obligation, a copy of your pamphlet "Gulf E. P. Lubricants for Rolling Mill Gears and Pinions."

Name.....

Company.....

Title.....

Address.....

HERE'S THE FIRST HIGH CONVECTION ANNEALING FURNACE DESIGNED ESPECIALLY FOR 430 CHROME STAINLESS STEEL

A typical charge of coils weighing approximately 32 tons.

Completely designed and built especially for annealing 430 chrome stainless steels, this line of Lee Wilson radiant convector furnaces was recently installed in the West Leechburg, Pa., plant of the Allegheny Ludlum Steel Corporation.

Designed for operation at 1525° F. and for a charge 60" in diameter by 120" in height, the yield per furnace is presently averaging 1 ton per hour, and a still better average is anticipated in the near future.

Lee Wilson

ENGINEERING *Co., Inc.*

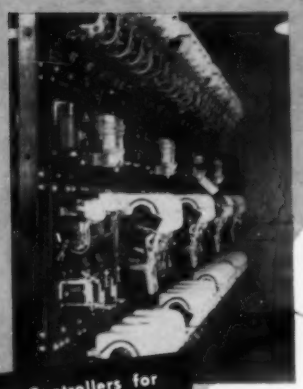
20005 WEST LAKE ROAD • CLEVELAND, OHIO
Telephone ED-1-6600

BELL TYPE FURNACES ★ RADIANT TUBE HEATING ★ ANNEALING PROCESSES

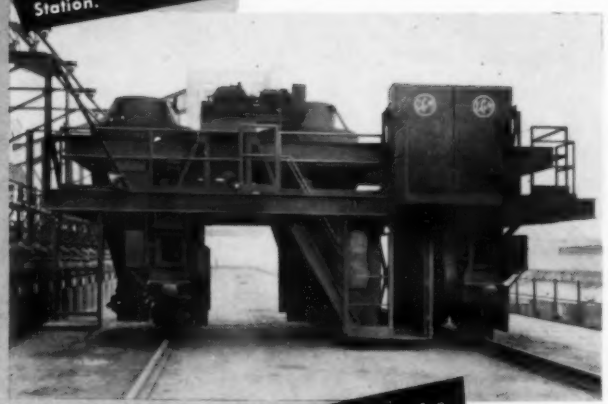
Coke Pusher built by Wellman Engineering Company, for the Willputte Coke Oven Division. Door-Machine is in left foreground.

Improved Operation

A GOOD REASON FOR SPECIFYING EC&M CONTROL FOR COKE OVENS



EC&M Controllers for automatically operating four car-hauls at the Coke Screening Station.



Koppers Larry Car for charging coal into ovens.

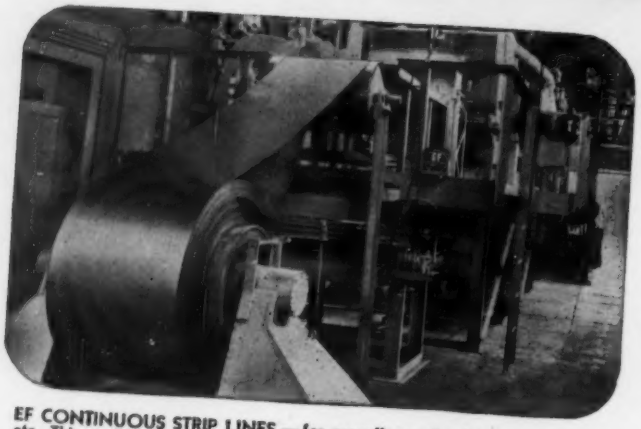
These coke oven machines are operated by EC&M Controllers using EC&M LINE ARC Magnetic Contactors and EC&M TIME-CURRENT method of acceleration.

EC&M Control has the reputation for being accurately engineered for the job and likewise designed for long life. This quality apparatus is known for its low upkeep.

When buying new machines or revamping existing installations, it pays to specify EC&M Control equipment.

THE ELECTRIC CONTROLLER & MFG. CO.

2698 EAST 79TH STREET • CLEVELAND 4, OHIO



EF CONTINUOUS STRIP LINES — for annealing, galvanizing, aluminizing, etc. This combination gas-fired and electric unit provides flexibility in controlled heating, soaking and cooling, for producing various surface and metallurgical conditions on ferrous and nonferrous strip. Built by The Electric Furnace Co., Salem, Ohio.

EF CONTINUOUS FURNACES are built in many sizes and types for processing wire, sheet, castings, stampings, strip, tubing and many other products. This EF gas-fired radiant tube special atmosphere furnace bright normalizes 3000 lbs. steel tubing per hour. Built by The Electric Furnace Co., Salem, Ohio.

EF builds Gas-Fired, Oil-Fired and Electric Furnaces for these and other heat treating operations

● EF engineers specialize in designing and building production furnaces — continuous and batch types — including roller hearth, roller rail, chain belt, wire belt, slot and tube conveyor types, reciprocating, rotary, car, bell, pit and other designs; complete with special atmosphere producers, and time and labor saving material handling equipment as required.

Reflecting more than 30 years of continuous research and experience, and outstanding engineering accomplishments, EF furnaces combine high heating efficiency, accurate automatically controlled cycles, and advanced designs that minimize maintenance, assure economy of operation, high hourly output and uniformity of product.

Submit your production furnace problems to ***experienced engineers — it pays.***

AGING
ANNEALING
ALUMINIZING
BRAZING
CARBON RESTORATION
CARBURIZING
CERAMIC DECORATING
DRAWING
GALVANIZING
HARDENING
HOMOGENIZING
MALLEABLIZING
NORMALIZING
NITRIDING
SINTERING
SOLUTION TREATING
SPECIAL ATMOSPHERE TREATMENTS AND OTHER PROCESSES

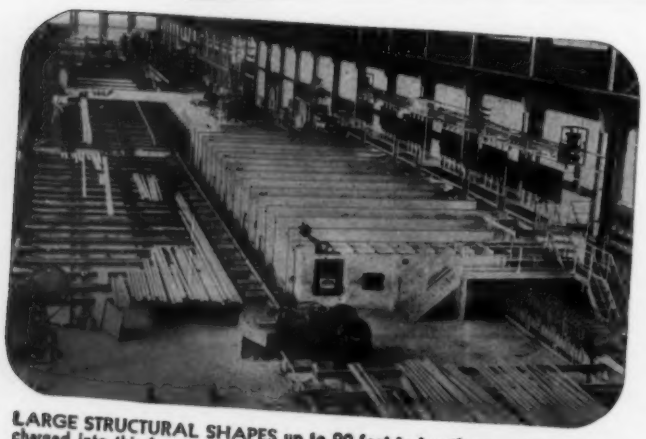
EF

THE ELECTRIC FURNACE CO.

GAS FIRED, OIL FIRED AND ELECTRIC FURNACES FOR ANY PROCESS PRODUCT OR PRODUCTION

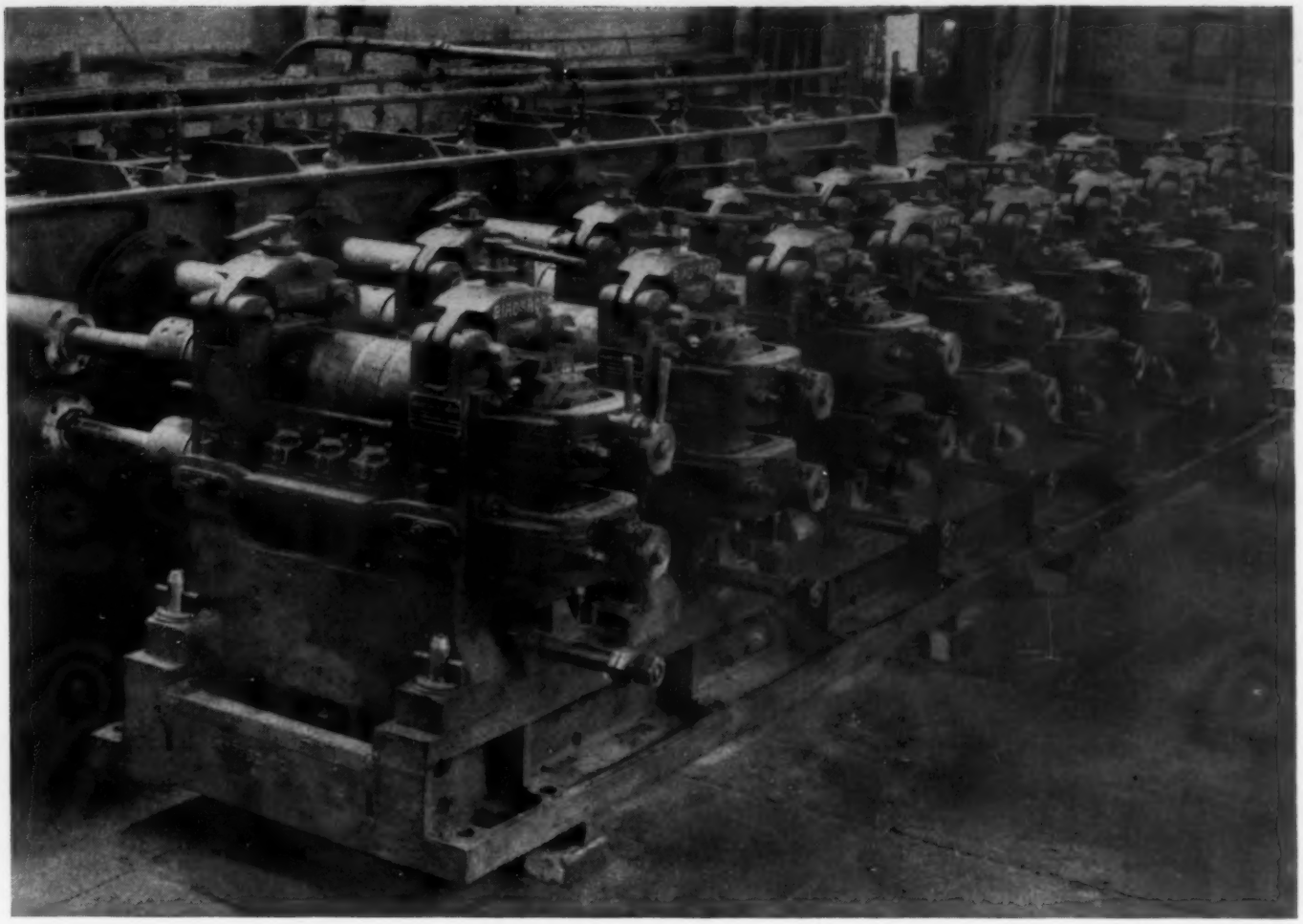
Salem - Ohio

Canadian Associates • CANEFCO LIMITED • Toronto 1, Canada



LARGE STRUCTURAL SHAPES up to 90 feet in length are automatically charged into this furnace, carried across the 93 ft. x 26 ft. heating chamber, uniformly heated and discharged thru a spray quench — everything is automatic. Built by The Electric Furnace Co., Salem, Ohio.

BRIGHT ANNEALING WIRE. An EF continuous bright annealing furnace in which the wire is conveyed through the various zones on two parallel rows of bulkhead type trays. This unit has convection cooling and handles 2500 net lbs. of wire per hour. Built by The Electric Furnace Co., Salem, Ohio.



MODERNIZE YOUR ROD MILL

for Increased Production... Lower Costs

Birdsboro's advanced engineering developed a new high speed finishing train, coilers and conveyors to modernize an existing mill. The eight stand finishing train is shown above at shop assembly.

If your production is lagging — or you find operating and maintenance costs are top heavy, call on Birdsboro. We are well equipped and have the engineering skill to modernize existing equipment—or replace it with the most up-to-date, efficient steel mill machinery.

BIRDSBORO

STEEL FOUNDRY & MACHINE CO.

Birdsboro, Penna.

Offices in Birdsboro, Pa. *and* Pittsburgh, Pa.

STEEL MILL MACHINERY

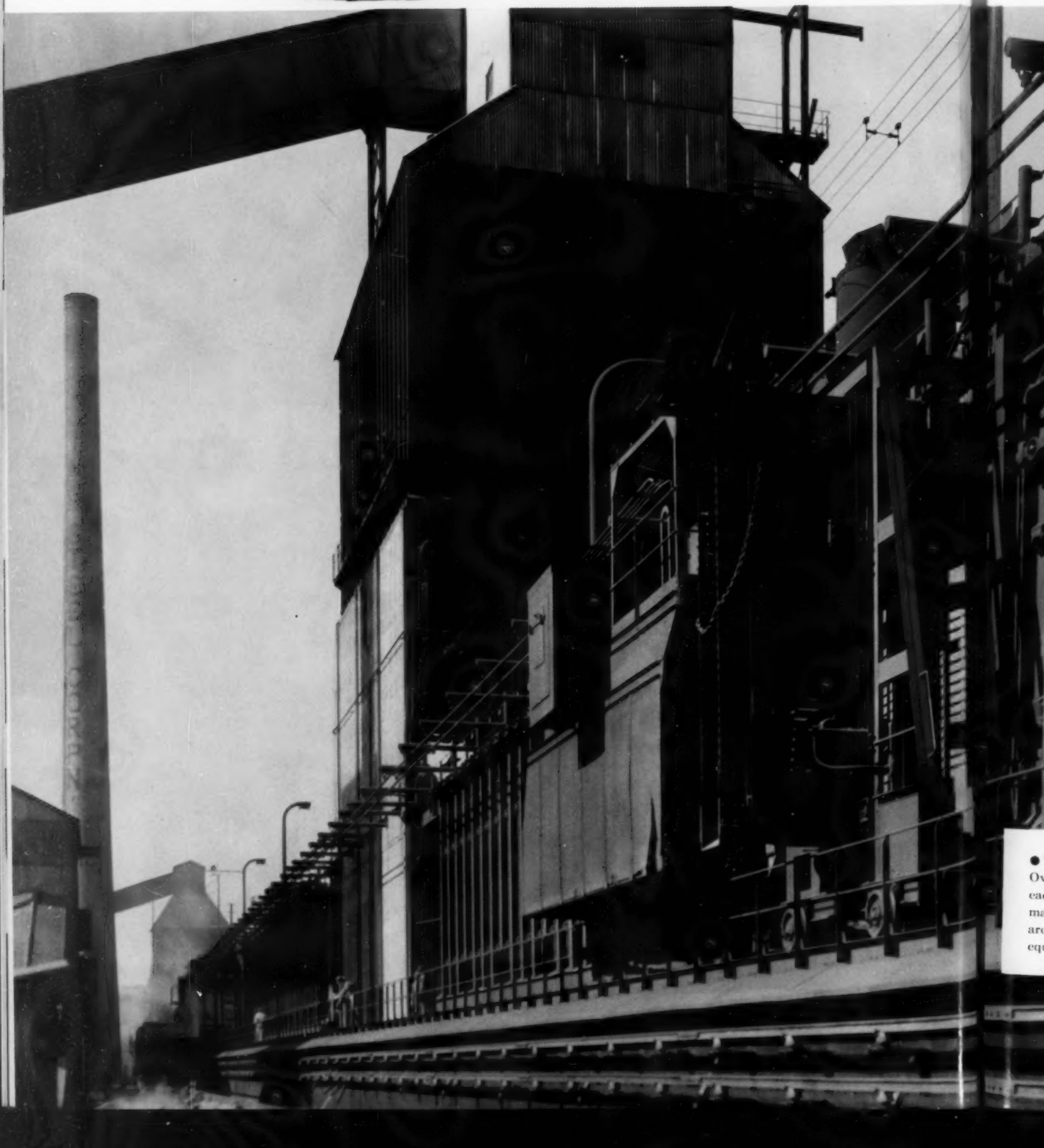
Designers and Builders of:

Steel Mill Machinery • Crushing Machinery • Rolls

Hydraulic Presses • Special Machinery • Steel Castings

MM 21-51-R

A B C's of



good coke-oven construction

● Typical Koppers-Becker Underjet Coke Ovens. Built in two batteries of 53 ovens each, these 106 ovens carbonize approximately 2,600 net tons of coal per day. They are underfired with coke-oven gas and are equipped with waste-gas recirculation.

A good basic design

The efficiency of any coke oven hinges entirely on its design. We believe that Koppers-Becker Coke Ovens have the best basic design. As a result, these ovens are sturdy, free from complications, simple to control. They also have the largest practical coking capacity.

This basic design meets diversified conditions. It can be employed when heating by any kind of fuel gas normally available, when building large or small ovens. This design results in low maintenance and in long life.

B constant engineering refinements

Koppers builds a great many coke-oven plants and is therefore in a position to anticipate new needs. For example, the waste-gas recirculation system was developed by us to meet the need for uniform heating when using rich fuel gas.

C skilled engineering staff

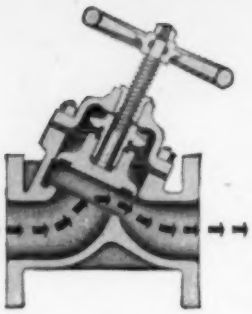
There is no substitute for a skilled engineering staff. Through the years, our engineers have proved their ability to design and erect the most advanced and efficient coal-carbonization equipment . . . material-handling systems . . . gas-treatment equipment.

Constructing coke ovens and related equipment is just one way in which Koppers serves the steel industry. For any kind of metallurgical construction, you can count on Koppers. You are invited to consult with our Engineers and Management.

KOPPERS

Engineering and Construction Division

KOPPERS COMPANY, INC., PITTSBURGH 19, PA.



FOR SAFER CONTROL ⟶⟶⟶ OF HARD-TO-HANDLE FLUIDS

CRANE Packless Diaphragm Valves

Now Available in New Materials

WORKING PRESSURES—up to 150 pounds. Water, air, oil, or gas, 180°F. maximum temperature, depending on valve size and materials.

You asked for it—and now Crane gives you this outstanding Diaphragm Valve in a new wide choice of body, disc insert, and diaphragm materials—in unlined or lined patterns. Whichever is specified, Crane design gives you important advantages including—long diaphragm life . . . positive shut-off in case of diaphragm failure . . . less resistance to flow with minimum pressure drop . . . easy operation . . . simplified maintenance at lowest upkeep cost.

Full specification data is in your new Crane 53 Catalog—or ask your Crane Representative.

SCREWED ENDS, UNLINED Sizes ½ to 2 in.
Brass, Cast Iron, Aluminum, or 18-8 Mo body and disc. Furnished with neoprene, Buna N, and natural rubber diaphragm and disc insert.

FLANGED ENDS, UNLINED Sizes ½ to 6 in.
Cast Iron, Aluminum, or 18-8 Mo body and disc. Furnished with neoprene, Buna N, and natural rubber diaphragm and disc insert.

FLANGED ENDS, LINED Sizes 1 to 6 in.
Cast Iron body only. Lined with neoprene or hard natural rubber. Disc coated with neoprene or soft natural rubber.

•

Other body and disc materials, as well as linings, available on special order. Also sliding stem valves for automatic operators of all types.

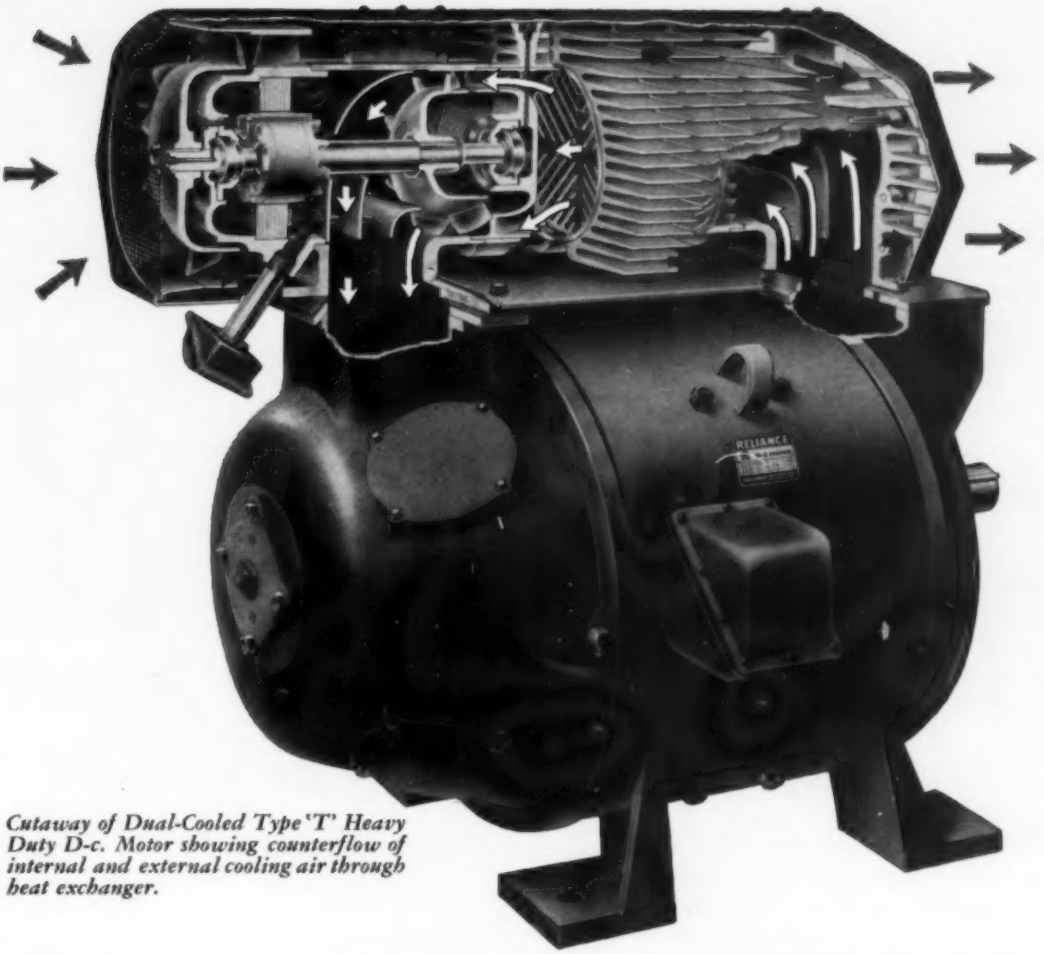
CRANE VALVES

CRANE CO., *General Offices:* 836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

RELIANCE *Totally-Enclosed* *Dual-Cooled* D-C. MOTORS

PATENT APPLIED FOR



Cutaway of Dual-Cooled Type 'T' Heavy Duty D-c. Motor showing counterflow of internal and external cooling air through heat exchanger.

for Wider Speed Ranges... Higher Ratings

New Reliance Dual-Cooled Motors provide dependable totally-enclosed, fan-cooled operation over wider speed ranges and higher ratings than were ever before possible . . . and this is accomplished with floor-space savings of up to 30%!

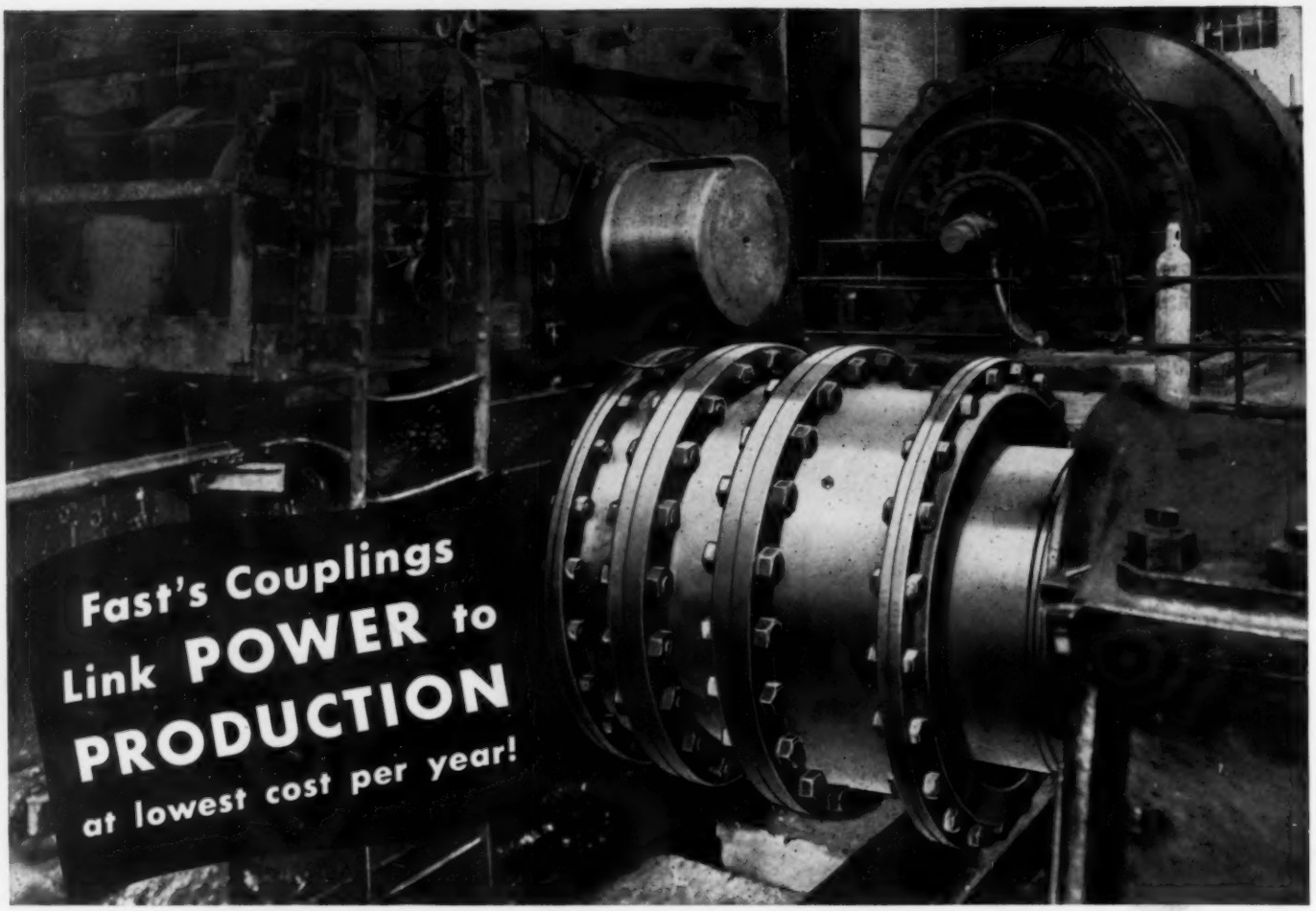
Dual-Cooled Motors are completely enclosed... have two separate cooling systems operating independently of the motor speed. One system circulates high-velocity air within the motor, that is cooled in the finned inner duct of the heat exchanger. This heat is dissipated in the other system by air sweeping through the fins of the outer duct.

The Dual-Cooled Motor is especially adaptable to Reliance adjustable-voltage V★S Drive and is available in ratings from 15 through 150 horsepower. Explosion-proof Dual-Cooled Motors are available through 100 hp., in conformity with Underwriters and Bureau of Mines specifications.

Whatever your application . . . get further details from the nearest Reliance Sales Office . . . or write for Bulletin C-2201.

RELIANCE ELECTRIC AND ENGINEERING CO.

1084 Ivanhoe Road, Cleveland 10, Ohio • *Sales Representatives in Principal Cities*



FAST'S Couplings usually outlast the equipment they connect!

ACTUAL cases on record show many Fast's Couplings are still in service after as much as 30 years of continuous operation! Time and time again, equipment has been replaced while the original Fast's Couplings remained on the job.

To you, these records of dependable, trouble-free service mean freedom from costly coupling failures when you specify Fast's. And they mean Fast's cost you far less to own and operate . . . because their cost can be amortized over long years of dependable performance.

For full details on how Fast's Couplings and Koppers Engineering Service can help you, write today for a free copy of our catalog to: KOPPERS COMPANY, INC., *Fast's Coupling Dept.,* 212 Scott St., Baltimore 3, Maryland.

Here's How FAST'S Save You Money

Free Service—Koppers free engineering service assures you the right coupling for the job.

Rugged Construction—Fast's still maintains its original design, without basic change or sacrifice in size or materials. Result: freedom from expensive coupling failures.

Lowest Cost per Year—Fast's Couplings usually outlast equipment they connect. Their cost may be spread over many years!

KOPPERS

FAST'S®

THE ORIGINAL GEAR-TYPE

Couplings

INDUSTRY'S STANDARD FOR 32 YEARS

KOPPERS COMPANY, INC., *Fast's Coupling Dept.,*
212 Scott St., Baltimore 3, Md.

Gentlemen: Send me Fast's Catalog which gives detailed descriptions, engineering drawings, capacity tables and photographs.

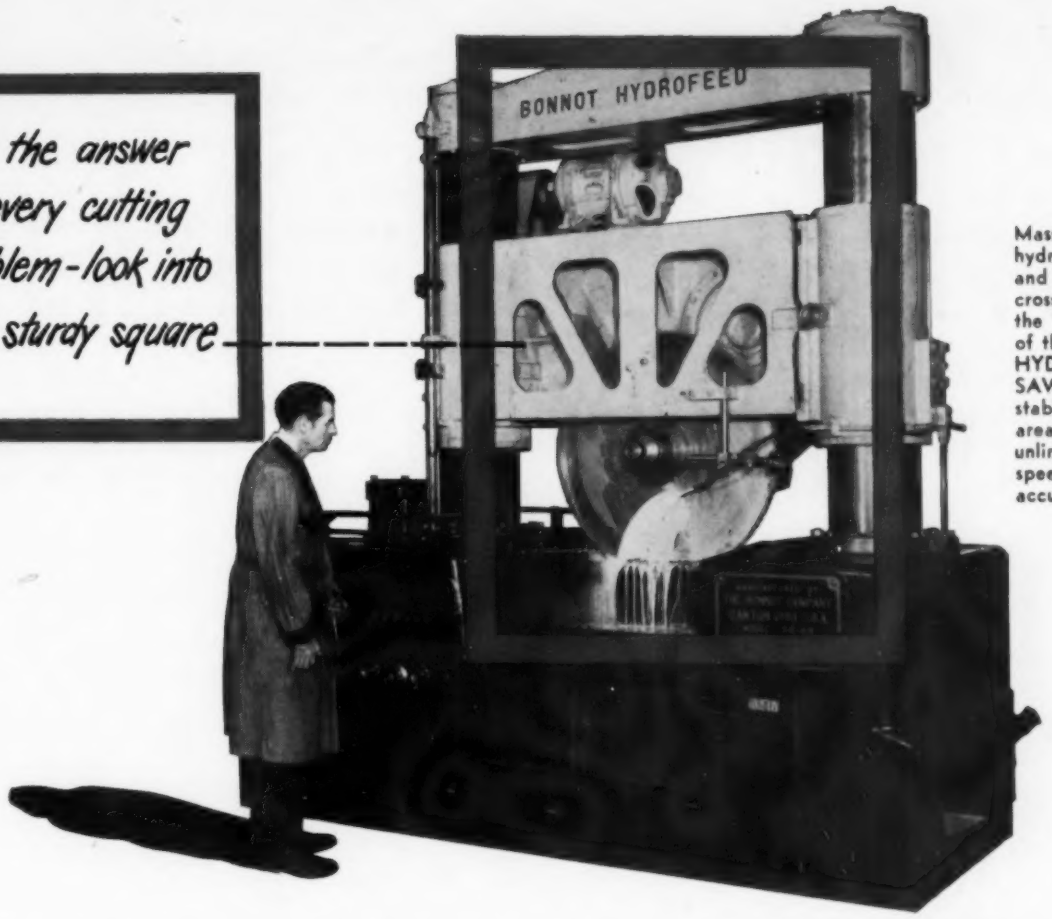
Name .....

Company .....

Address .....

City ..... *Zone* ..... *State* .....

For the answer to every cutting problem - look into this sturdy square



Massive base, huge hydraulic columns and one-half ton crosshead enclose the "sturdy square" of the Bonnot HYDROFEED COLD SAW. This assures stability of working area that means unlimited cuts at high speeds . . . perfect accuracy every time.

IT'S THE RUGGED HEART OF THE HYDROFEED BILLET AND BAR COLD SAW!

Engineered for continuous, 'round-the-clock performance—for a vastly stepped-up output and for "sharp pencil" economy — the *Bonnot* HYDROFEED COLD SAW stands alone in modern cold-sawing techniques and efficiencies. Automatic, high speed, vertical feed, it brings you a full "baker's dozen" of advantages unmatched by any other method!

Check these Features! Count them Too!

1. POSITIVE FEED CONTROL
2. ACCLIMATED TO ALL WEATHER
3. RIGID CONSTRUCTION
4. CHATTER-FREE OPERATION
5. SAFETY CONTROLS—FOR OPERATION AND MACHINE PARTS
6. ADJUSTABLE PRESSURE CONTROL
7. CUTS WIDE RANGE OF SIZES, SHAPES AND ANALYSES
8. PERMITS SELECTION OF FEEDS AND SPEEDS
9. PROVIDES HIGH VISIBILITY FOR OPERATOR
10. HIGH SPEED CUTTING AND CARRIAGE RETRACTION
11. SELF-CONTAINED HYDRAULIC SYSTEM
12. AUTOMATIC VOLUME CONTROL
13. EASY ACCESSIBILITY FOR MAINTENANCE

Now Get the WHY of Each Advantage

A Bonnot Engineer will be glad to show you how the "baker's dozen" of HYDROFEED features can be applied in your plant—profitably, effectively. Write, wire or phone today!

Engineered For Improved Production

The Bonnot Co.
STEEL EQUIPMENT DIVISION
CANTON 2, OHIO

Also Manufacturers of — SAWING • CRUSHING • PULVERIZING AND MIXING EQUIPMENT • BILLET INSPECTION TABLES
DUST PUG MILLS • SINTER PLANT PUG MILLS

MORE BLAST FURNACES HAVE BEEN LINED WITH OLIVE HILL BRICK

than with any other brand!

Yes, OLIVE HILL blast furnace brick have lined more blast furnaces than any other brand! OLIVE HILL holds the most records for daily, weekly, monthly and yearly output and for greatest tonnage and length of service.

Reasons for Top Quality

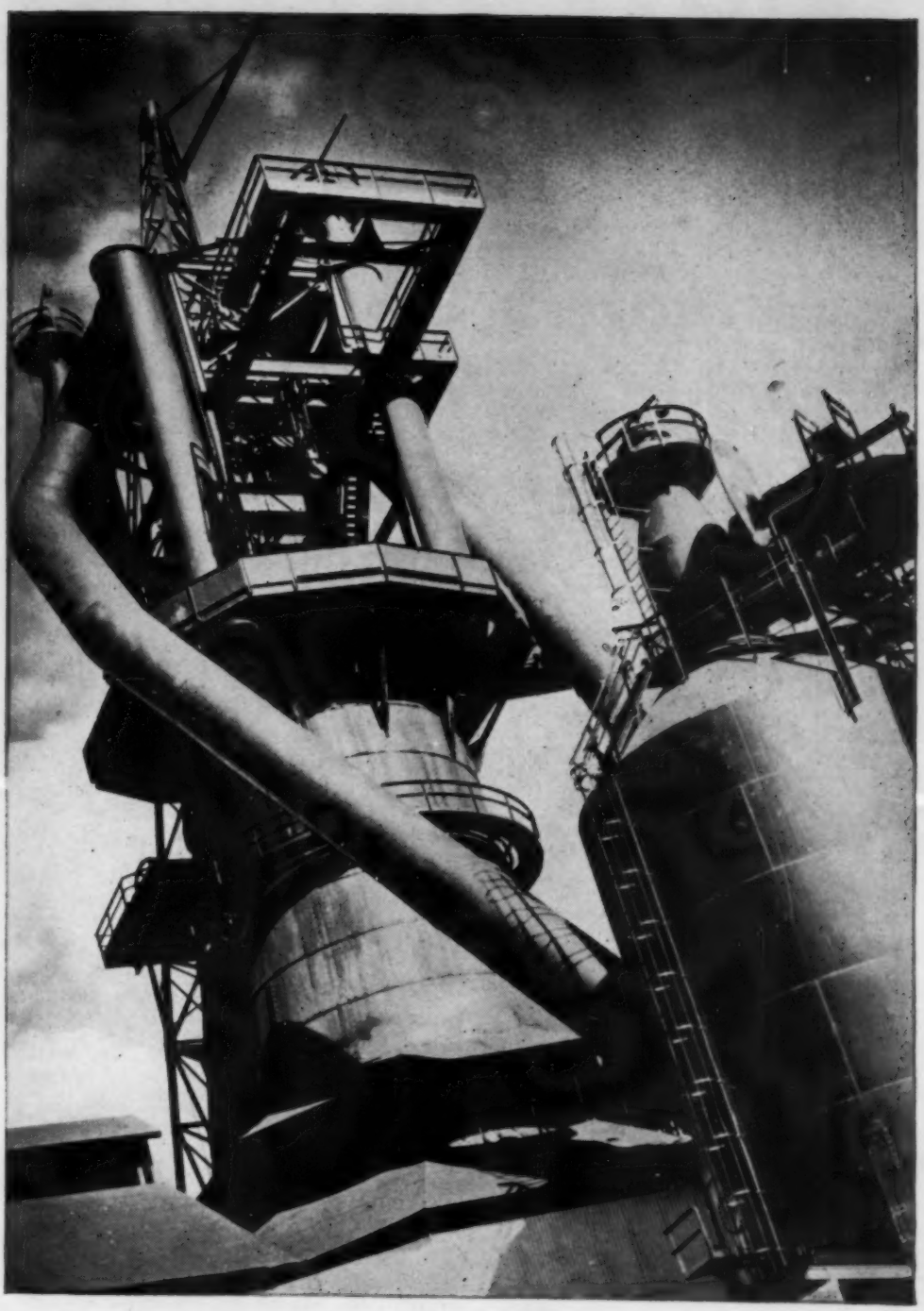
The unrivalled, industry-wide record of OLIVE HILL is due to: *unique fireclay* and *superior processing*. Grefco produces OLIVE HILL—from Kentucky fireclay, unmatched in suitability for blast furnace brick—using constant control of every step: scientific grain sizing, efficient methods of de-airing, special brick-sizing, and accurately controlled burning.

OLIVE HILL Regular and HI-FIRED

The temperature at which OLIVE HILL is burned gives brick of high refractoriness, high density, low porosity, good resistance to carbon disintegration, excellent resistance to abrasion, and high ability to carry load. OLIVE HILL HI-FIRED (Cone 18) brick are virtually immune to carbon disintegration, and have even greater density, lower porosity, and higher resistance to abrasion and deformation under load.

Whether you prefer OLIVE HILL or OLIVE HILL HI-FIRED, or a combination, you may be sure that OLIVE HILL will give you the *world's best value* in blast furnace brick.

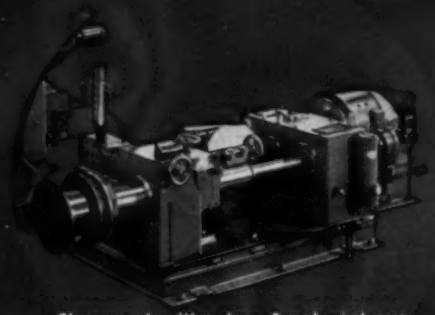
GENERAL REFRACTORIES



GENERAL REFRACTORIES COMPANY
PHILADELPHIA

THIS WF WIRE FLATTENING TEAM

. . . SQUEEZES "DOWN-TIME", TOO



Close-up of a Waterbury Farrel winder at the delivery end of a WF Tandem Mill. Winder is provided with pneumatic clamping of reels. It has three adjustments for width of wire and width and positioning of drum or spool.

This complete Waterbury Farrel mill package includes 10" and 8½" Tandem Wire Flattening Mills, power driven double head Pay-off, Edger, Winder, footage counter, continuous thickness and width gauges and automatic electrical synchronizing control. Other WF tandems with up to five mills available.

Modern Waterbury Farrel Mill Design Insures High Production Plus Precision . . . Minimizes "Down-Time"

Here are some reasons why Waterbury Farrel Wire Flattening equipment can give you *more continuous,* high speed, precision production.

- Loading payoff and motor driven screwdowns for mills and edgers facilitate threading of wire with minimum effort and time.
- To protect precision operation, soluble oil is circulated internally and externally on the rolls and into coolant enclosures where wire is submerged. A refrigeration system maintains the coolant oil temperature at approximately 70° while a flotation unit keeps it clean and fresh. In addition, high speed mills also have a self-contained, automatically-filtered circulating mineral oil lubrication system for roll necks and drives.
- Transparent lucite covers at vital lubrication points such as gear cases and universal joints make it easy to check lubrication at a glance.
- Anti-friction bearings are used for all rotating members including the winder shaft. High precision anti-friction bearings are used on roll necks and edger arbors. This, combined with precision fitting of component parts enables WF mills to maintain tolerances well inside commercial allowance.
- Tungsten carbide ring rolls permit rolling the toughest alloys and increase roll life.
- Electric control keeps wire tension constant. Dancer rolls are used for fine wire.

Waterbury Farrel designs and builds a wide range of wire flattening mill equipment to suit specific requirements. Various sizes and combinations of single and multiple mill stands with auxiliary equipment are available for flattening ferrous and non-ferrous wire from the smallest diameters to 1" diameter and more. Speeds range up to and above 2500 FPM.

Write for further information.

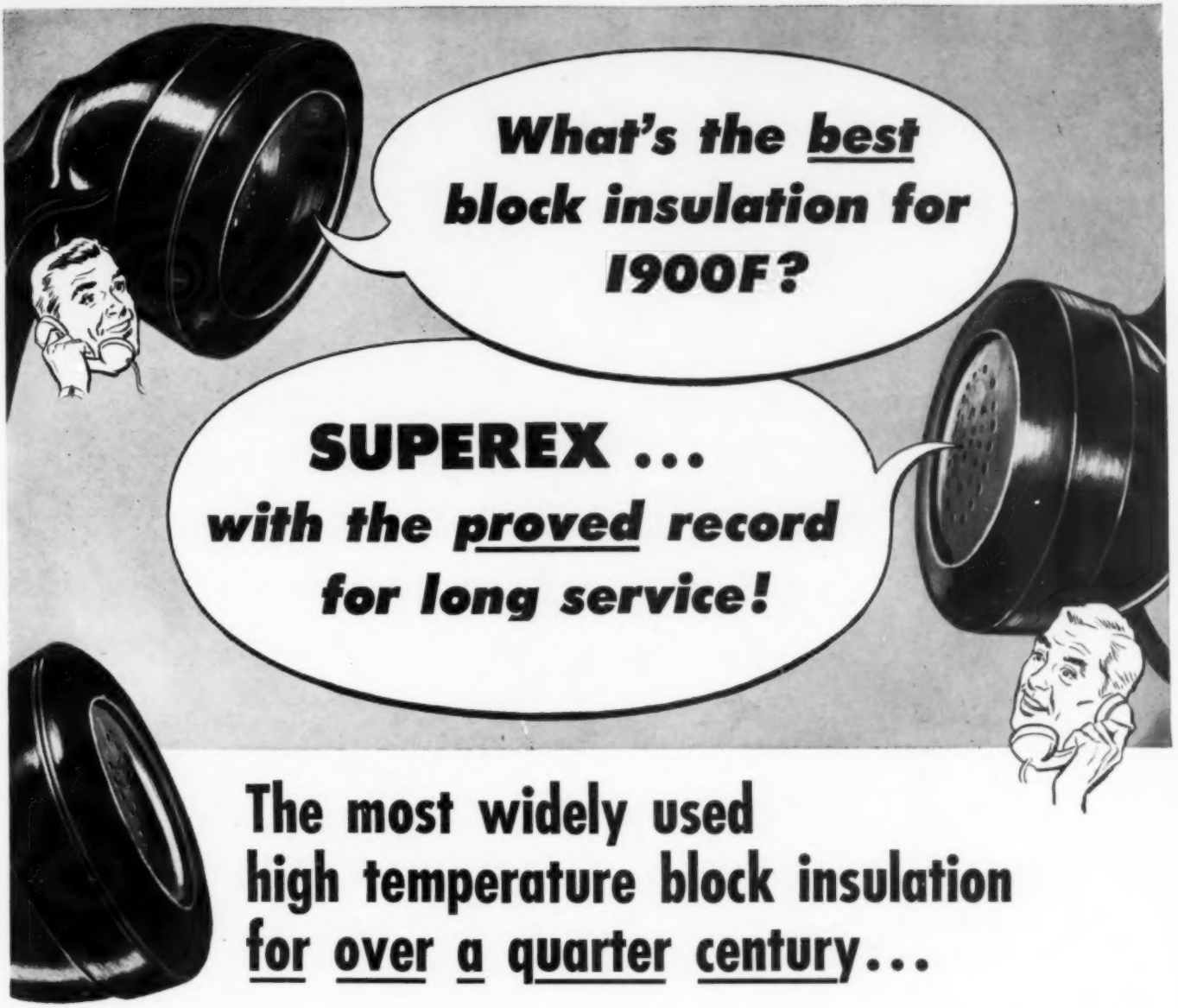
WATERBURY FARREL FOUNDRY & MACHINE CO.
WATERBURY 20, CONN.
***Sales Offices:* Chicago, Cleveland, Millburn, N. J.**

WATERBURY FARREL FOUNDED 1851

A FEW OF THE MANY TYPES OF METAL WORKING MACHINERY MADE BY WATERBURY FARREL

MILL MACHINERY—Rolling Mills: Strip, Rod, Wire Flattening. (For Ferrous and Non Ferrous Metals) • Also Slitters • Straighteners • Cut-off Saws • Coilers • Winders, etc. *WIRE MILL EQUIPMENT*—Continuous Wire Drawing Machines (Upright Cone and Tandem) • Wire Flattening Mills • Chain Draw Benches • Pointers Swagers • Bull Blocks • String-up Machines • Spoolers, etc. *COLD PROCESS BOLT & NUT MACHINERY*—Headers (all types) • Rivet Machinery • Trimmers • Thread Rolling Machines • Slotters • Nut Formers and Tappers, etc. *POWER PRESSES*—Crank, Cam and Toggle; also Rack and Pinion Presses • Eyelet Machines Multiple Plunger Presses • Horizontal and Hydraulic Presses, etc.

WF 9



The most widely used high temperature block insulation for over a quarter century...

SUPEREX® high temperature block insulation has long been industry's No. 1 choice for service temperatures up to 1900F. It provides *major* economies . . . reduces fuel costs, cuts heat losses, keeps maintenance expense down, costs less to install and has long service life.

These are the reasons why 90% of the nation's hot blast stoves are Superex insulated . . . and why the low cost open hearth steel producers use Superex in their regenerators.

Made of specially selected and calcined diatomaceous silica blended with other insulating materials and bonded with asbestos fiber, Superex will safely withstand temperatures up to 1900F with negligible shrinkage.

Superex has been used with outstanding success in all types of industrial and metallurgical furnaces and ovens, stationary and marine boilers, auxiliary power plant equipment, regenerators, kilns, roasters, high temperature mains, flues and stacks.

Superex has all these important advantages...

Low thermal conductivity—Exceptionally high heat resistance (1900F) combined with excellent insulating value.

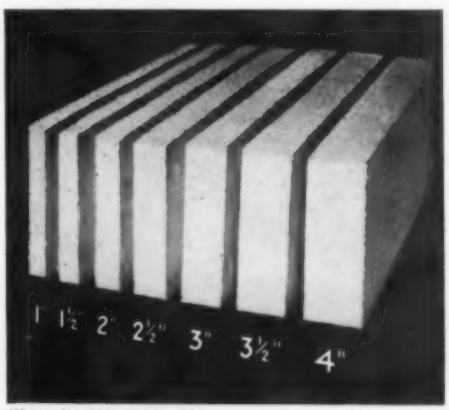
Light weight—Approximately 2 lb per sq ft per in thickness.

Great physical strength—Approximately 6 tons pressure per sq ft are required to compress Superex ½ in.

Long, efficient service life—Superex maintains high insulating value indefinitely—will not disintegrate in the service for which it is recommended.

Fast, easy application—Superex may be cut with an ordinary knife or saw for fitting around openings or to irregular surfaces. Because of its light weight and convenient sizes, Superex assures fast and economical installations.

For complete information about Superex block insulation, write for Brochure IN-134A. Address Johns-Manville, Box 60, New York 16, N. Y. In Canada, write 199 Bay Street, Toronto 1, Ontario.

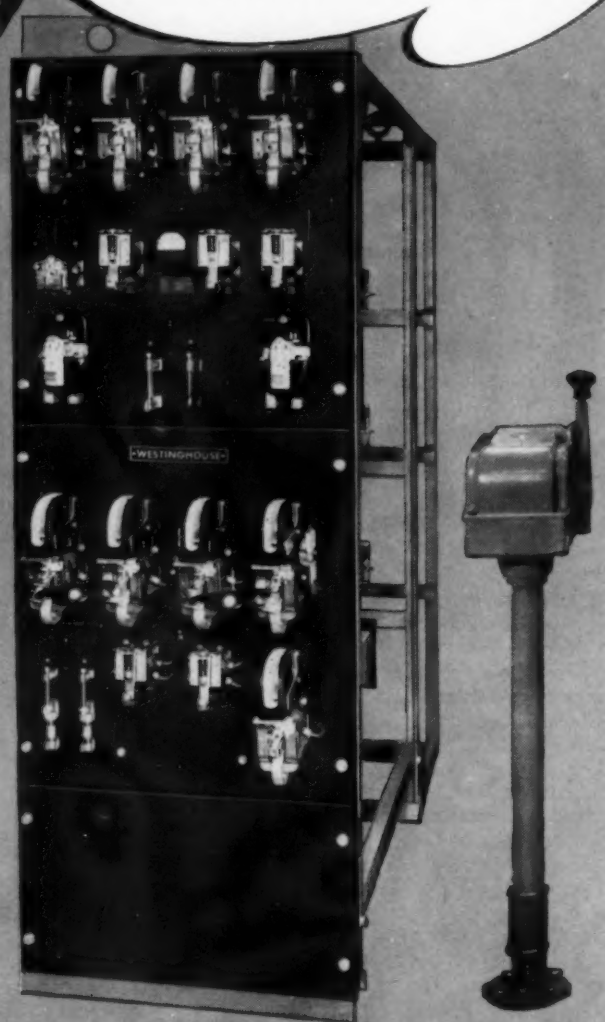


Waste is minimized with Superex because of the variety of thicknesses available. Special shapes and intermediate thicknesses between those shown are also available.

JOHNS-MANVILLE JM PRODUCTS **Johns-Manville** *first in* **INSULATIONS**

Mill Motor
PAIRED FOR PRODUCTION
Mill Motor Control

600 Series Mill Motor



Typical 9500
Line Controller, Type M
Contactors and Type SM
Master Switch

Rugged!

cut mill down time with this team

Certainly in a mill, where down time costs add up fast, the ability of equipment to stand up to rugged continuous duty is of paramount importance. That's why you'll find this combination hard to beat. They are rugged . . . made together to work together. Each incorporates the latest design features to keep production lines rolling.

Take the motor for example. The high starting torque of this new 600 series mill motor is ideal for high inertia loads . . . proved commutation . . . high rated efficiency assures maximum performance under tough service conditions . . . simplified construction makes servicing and maintenance easy. It is a brand-new motor with a new kind of performance built for today's tougher jobs.

Controllers, too, are built to assure new dependability. Main contactors are the new Type M with knife-edge, trouble-free bearings . . . with exclusive Quick-Quench arc boxes which greatly increase contact life. Overload relays are the dual thermal instantaneous type. Accelerating relays are the time-proved inductive time delay Type AZ.

The third part of this control team is the rugged Type SM master switch. Easy to operate, yet with a definite "feel" for each operating point of position, the switches are available with 2 to 6 speed control.

Together, these three offer a new kind of dependability. Get the facts on all three. Ask your nearby Westinghouse representative for a copy of the new booklet B-4730, or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-21647-A

YOU CAN BE SURE...IF IT'S Westinghouse

Amsco Chains Get Tougher With Use

How AMSCO Manganese Steel Chains Acquire Progressively Greater Resistance to Impact and Abrasion.

Actual case histories prove that AMSCO Manganese Chains outlast ordinary chains by more than 6 to 1 where impact and abrasion exist. For example, on one conveyor operation, ordinary chain had to be completely replaced every three months. When AMSCO Manganese Steel Chain was installed, only a small fraction of the links were replaced during a test period of over 24 months.

Users of AMSCO Chains benefit by unusual freedom from expensive chain replacement, breakage, maintenance-down-time and other problems caused by impact and abrasion conditions.

AMSCO Manganese Steel Chains have the unique ability to work-harden with use. In rough service, they develop a surface hardness up to 500 Brinell. They also acquire a hard glass-like polish that helps shrug off grinding abrasion. All AMSCO Manganese Steel products — tough when produced — possess the extra-value quality of actually increasing durability with in-use battering and grinding.

AMSCO Chains are made of Manganese Steel —the "Toughest Steel Known." They are produced in many standard and special shapes by American Manganese Steel Division—largest producer of manganese steel for all industry.

If you use chain, and desire a more durable alloy, you are invited to contact AMSCO. There's a good chance we can save you money and provide chains that will outlast your service life expectations.

AMERICAN Brake Shoe COMPANY

AMERICAN MANGANESE STEEL DIVISION

411 EAST 14th STREET • CHICAGO HEIGHTS, ILL.

Other Plants: New Castle, Del., Denver, Oakland, Cal., Los Angeles, St. Louis. In Canada: Joliette Steel Division, Joliette, Que.
Amsco Welding Products distributed in Canada by Canadian Liquid Air Co., Ltd.

Patent Reviews

By MELVIN NORD
Patent Attorney
Detroit, Michigan

. . . . copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents each . . . .

POURING NOZZLE FOR LADLES

▲ IN U. S. 2,615,216, by Edwin E. Slick, a novel type of pouring nozzle is disclosed which is claimed to give much longer service than the conventional type of nozzle.

As shown in Figure 1, a single-piece nozzle, 2, is used at the bottom of ladles, together with a plug 3 which seats in the upper part of the nozzle. The nozzle contains a cylindrical passageway 4 throughout its length,

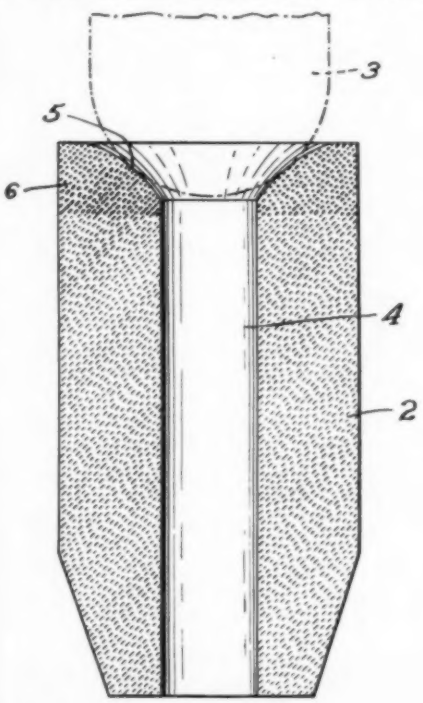


Figure 1

permitting the discharge of molten metal. At the upper end of the nozzle, the passageway 4 flares outwardly providing a seating surface 5.

The first few inches at the top of the nozzle, in the region designated as 6, consist of a refractory which is softer under operating conditions than the remaining part of the nozzle, that is, of clay of a slightly lower softening point. For example, the softening point of the clay in the main body of the nozzle may be 3000 F, while that of the clay at the top may be 2700 F. The two bodies of clay are bonded together in the operation of molding the nozzle, and constitute an integral one-piece body when the entire nozzle is fired. Other ways of making the seating part of the nozzle softer than the remainder of the nozzle are described in the patent specification, including the use of a flux in the upper part of the clay nozzle.

The use of the softer material at the top of the nozzle provides in effect a valve seat which will accommodate itself under the conditions of use to the seating of the plug. The remainder of the nozzle, being harder, resists erosion.

SIDE-CHARGING CUPOLA WITH COLLECTION OF DUST FROM GASES

In U. S. 2,618,548, by John F. Drake, assignor of one-half to Theodore G. Kennard, means of adapting side-charging cupolas for the collection of dust are disclosed.

Cupolas are commonly constructed with a discharge stack for waste gas and dust directly above the cupola structure. Charging of the scrap iron and coke is effected through a side opening near the top of the cupola and below the stack. This opening at times may be closed or partly closed, but in any event air is purposely admitted through this opening for the combustion of carbon monoxide which is evolved during the operation of the cupola. The burning gases around and above the door generate much useless heat at this point, and greatly increase the volume of gas discharged through the stack. The high temperatures caused by the burning of this gas around the charging door shortens the life of the equipment.

If tightly closed doors are provided, the gases discharged to the atmosphere will contain large amounts of poisonous carbon monoxide whose discharge into the air is highly undesirable and is forbidden by law. Furthermore, the increasingly stricter requirements of communities for the elimination of dust and fumes requires that the gases be treated before discharge to the atmosphere to remove the particulate matter, fumes, and smoke. If the entire amount of the gaseous discharge from the stack is to be subsequently treated for the removal of particulate matter, it is desirable that the volume of gas be held to a minimum, and it is also desirable that the temperature of the gas collected for treatment should be as low as possible, so that steel conducting pipes may be used to convey the dust-laden gases to the treating equipment.

Because of the generation of carbon monoxide in the normal opera-

tion of a cupola, it is undesirable merely to confine the gaseous discharge or to close the top of the cupola for collection of the gases with subsequent treatment for removal of solid contaminants. Furthermore, when the cupola top has been closed off from the stack, the volume of gases to be treated is reduced to a minimum, but there remains the danger of forming explosive mixtures of carbon monoxide and air in the gas-treating equipment outside the cupola. Because of the present existence of elaborate cupola equipment which is designed for use with a side-charging door rather than with a closed bell type charger, which, except for the great expense, might be added to existing cupolas, the modification of already built and operating cupolas to effect the collection and treatment of the gaseous discharge has been costly and unsatisfactory. The present patent discloses a method and equipment for adapting present cupolas to meet these demands.

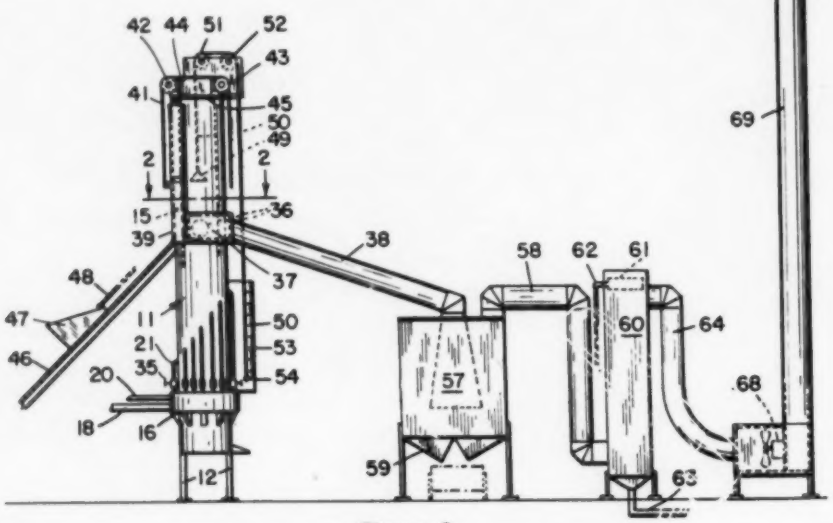


Figure 2

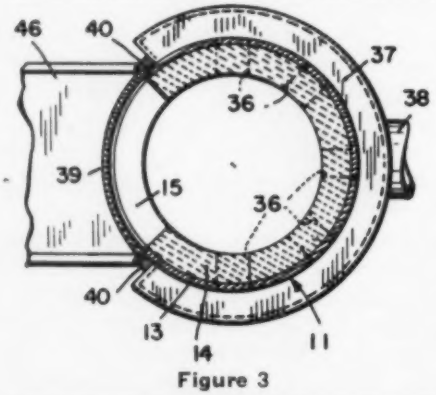


Figure 3

As shown in Figure 2, a cupola furnace 11 is mounted on piers 12, and consists of a cylindrical steel shell 13 having a fire brick lining 14 which terminates near the charging opening 15. Figure 3 is a cross-section taken on the line 2-2 of Figure 2, immediately above the charging opening 15. Figure 4 is an enlarged cross-sectional view of the lower part of the cupola, showing tuyeres and secondary air inlets. Tuyeres 16 are provided near the bottom of the cupola to admit primary combustion air under pressure through openings in the brick lining. The tuyeres are connected through a primary air manifold 17 extending around the cupola, into which air is admitted through pipe 18. A secondary air manifold 19 is also provided, with an air pipe 20. Secondary air inlets 21 to 32 are connected at the lower end to the secondary air manifold 19 and extend into the shaft of the cupola furnace above the melting zone at several elevations. Each inlet pipe is provided with a valve 35 to regulate the air admitted.

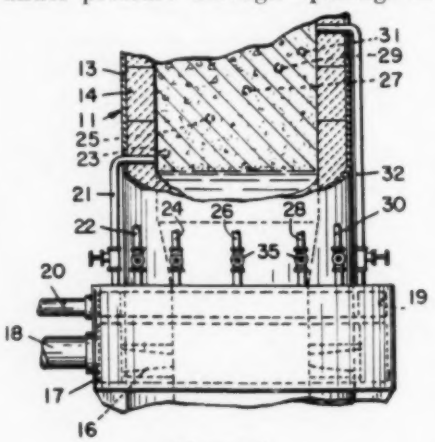


Figure 4

At elevations corresponding to the elevation of the charging door, take-off openings 36 distributed around the periphery of the cupola are provided. These are connected to a take-off manifold 37 which communicates through the pipe 38 with dust-collecting equipment shown in Figure 2.

The charging opening 15 is provided with a vertically sliding door 39, the door being raised and lowered by means of a cable and pulleys. Charging may be by hand or by means of an inclined track and skip car, as shown in Figure 2. The upper level of the charge in the cupola is ascertained by means of a gauge weight 49 suspended on the cable 50 over pulleys 51 and 52. A marker 54 is provided at the other end of the cable to indicate the position of the charge.

The admission of air above the melting zone through one or more of the secondary air pipes prevents the discharge of carbon monoxide in substantial amounts. When the cupola door is opened for charging, suction from the fan 68 is applied, thus preventing loss of gases directly to the atmosphere. No burning of carbon monoxide occurs when air is thus drawn through the charging door, since the concentration of carbon monoxide has already been decreased below the explosive limit.

HEAT-TREATMENT OF HARDENABLE STEEL

In U. S. 2,618,284, by Charles G. Purnell, assigned to United States Steel Corp., a method and apparatus are disclosed for hardening steel by heat treatment.

The objects of the method are to produce a non-martensitic hard structure without the danger of quenching cracks, and without the necessity of holding the steel at a constant temperature for a relatively long time.

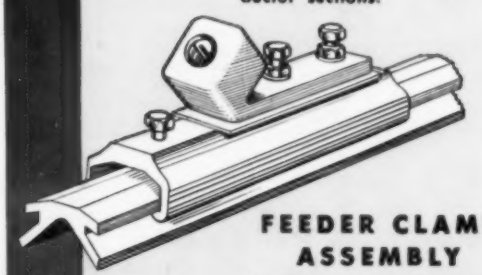
After heating the steel above the lower critical temperature and completing the transformation of all the ferrite to austenite, the steel is quenched faster than the critical cooling rate to a temperature below the desired isothermal transformation temperature corresponding to the desired structure. However, the temperature attained is not low enough for martensite to be formed, as indicated in the S curve, Figure 5. The steel is then reheated rapidly to a temperature high enough for the

(*Continued on page 36*)

The Keystone INTEGRATED ALUMINUM* Conductor System

HANGER SECTION
Conductor free to slide within support, allowing for expansion and contraction.

JOINT PLATE AND BOND ASSEMBLY
Non-loosening spring-type splice plate provides excellent electrical and mechanical joint characteristics between conductor sections.



FEEDER CLAMP ASSEMBLY
features a bimetal separator that eliminates galvanic corrosion between copper terminal and aluminum surface, providing foolproof, long-lasting connection.

LOWER COST
LIGHTER WEIGHT, HIGHER EFFICIENCY
SAFER ENCLOSURES

An integrated power supply system designed to complement the best materials handling equipment—1000 amperes capacity for heavy duty systems . . . economical for use on control circuits.

The Keystone Aluminum Conductor System is now being employed in outstanding installations, after having been developed through years of research in the laboratory and industry. It has been carefully designed to solve the troublesome problems formerly encountered.

The light weight of this conductor system reduces costs of installation, insulators and supporting structures. Its non-corrosive qualities permit use on sensitive control circuits. Longer contact life. Compact design saves space, permits better protection. All components are pre-fabricated. Available complete with brackets and enclosures. No copper boosters nor priorities needed. Easily engineered, installed and maintained.

*Domestic and Foreign Patents Pending

Write today for new, illustrated 4-page folder on Keystone Integrated Aluminum Conductor System.

ELECTRIC SERVICE MANUFACTURING CO.

PHILADELPHIA 32, PENNA.

desired transformation to occur, and it is held at approximately this temperature until the transformation occurs, after which the steel is cooled as desired.

The advantage of this method over the normal isothermal transformation method is that the austenite is conditioned by the supercooling so that the transformation occurs much more rapidly than it otherwise would. It is also more economical in view of the fact that it is possible to use brine or a light oil as the quenching medium.

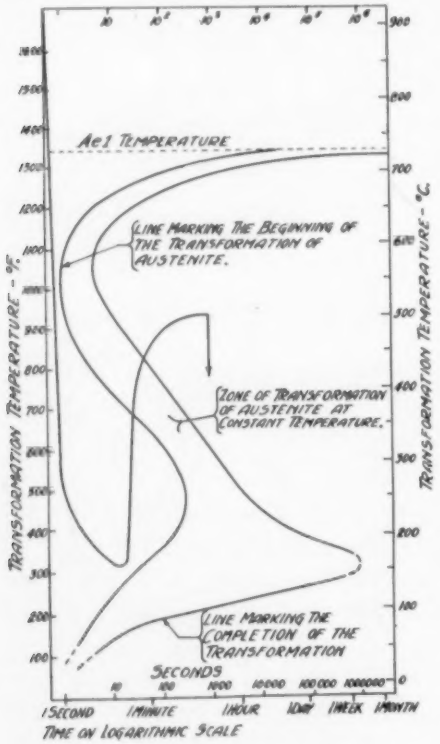


Figure 5

It is claimed that the method will produce fine pearlite or spheroidized cementite in large as well as small sections. However, it is not applicable to articles containing both large and small masses. That is to say, if the treatment is successfully applied to the large mass, the small mass may be unavoidably cooled low enough to form martensite, while if the treatment is successfully applied to the small mass, the large mass may not be supercooled sufficiently to provide the desired acceleration of the transformation rate. If the small mass becomes martensitic during the cooling, it normally becomes tempered during the reheating of the large mass.

The claims in the present patent are directed to an apparatus for carrying out the heat treatment described. The method itself was claimed in U. S. 2,322,777, which was issued June 29, 1943.

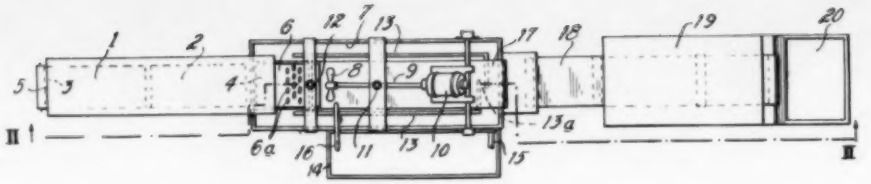


Figure 6

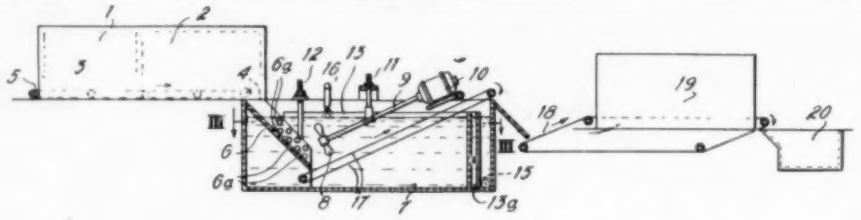


Figure 7

The apparatus disclosed in the present patent is shown in Figures 6, 7, and 8. Heating and transformation to austenite are accomplished in a continuous furnace having heating chamber 1 and soaking chamber 2. Quenching is accomplished by dropping the piece down a perforated chute 6, through the holes of which the quenching liquid is circulated by means of the agitator and propeller. The piece is then removed automatically by a continuous conveyor 17,

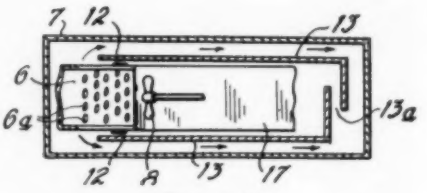


Figure 8

where it enters the reheating furnace 19. The steel finally drops into the cooler 20. The entire operation is thus continuous. Adjustment of the cooling rate in the quenching chamber are made through changing the slope of the chute 6 and the position of the propeller.

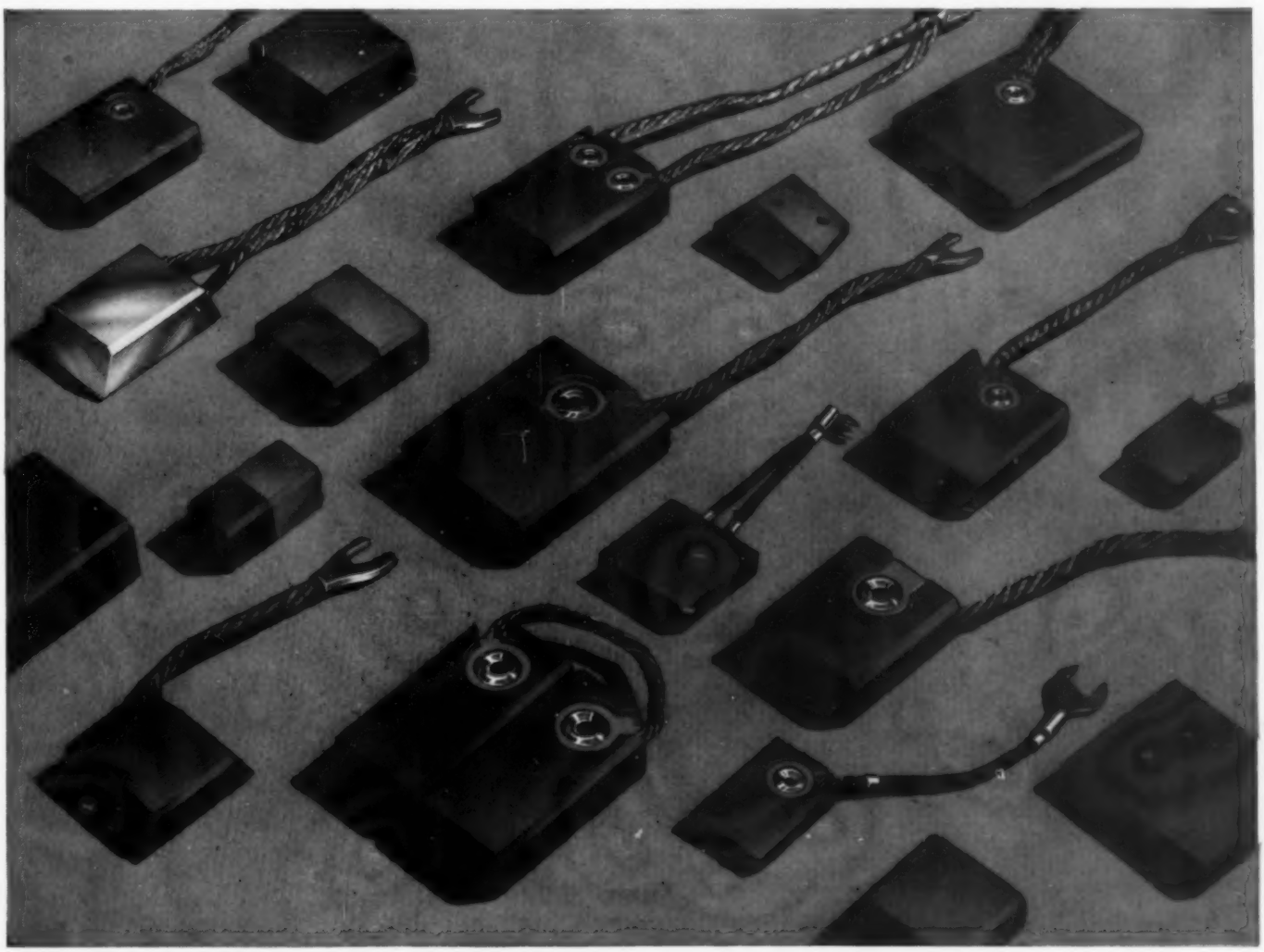
OTHER PATENTS OF INTEREST TO IRON AND STEEL ENGINEERS

Patent No.	*Subject of Patent*	*Inventor or Assignee*
2,615,306	Forging apparatus and control thereof	Chambersburg Engineering Co.
2,615,355	Stock gauge trip for a rolling mill	National Machinery Co.
2,615,412	Press for drawing sheet metal	Charles J. Rhodes
2,616,137	Core for tubular ingot molds	Benjamin Brownstein
2,616,185	Spacing gage assembly for mill rollers	Roy F. White
2,616,325	Tube chamfering and cut-off mechanism	The Etna Machine Co.
2,616,679	Furnace for heating metal bars	Morgan Construction Co.
2,617,467	Apparatus for coiling sheet metal into rolls	Frederick Iron & Steel Co.
2,617,643	Machine for surface-hardening gear teeth	Gleason Works
2,618,031	Centrifugal casting machine	Mazer Bros., Inc.
2,618,438	Breaker bar screen for rigid hammer crushers	The Jeffrey Manufacturing Co.
2,618,578	Blackening stainless steel	Armco Steel Corp.
2,618,592	Electrolytic process for recovery of by-products from waste pickle liquor	Gerald J. Horvitz

BUY USG BRUSHES

Try USG Brushes. They will solve those tough application problems for you. • Complete manufacturing facilities, plus continuous research and engineering make USG Brushes and Contacts the best you can use on all rotating electrical equipment. • USG BRUSHES can do a *better* job for you . . . Let us arrange a performance test to prove it.

Write today for 40-page catalog giving complete information on standard USG grades.



90-B

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN

Rear view of an actual blast furnace installation showing 4 sections of a MULTI-DUTY Air Filter—Capacity of 105,000 cfm.

it takes **CLEAN AIR** to operate a blast furnace **AT A PROFIT**

The mighty volumes of air fed to the hungry blast furnaces of the nation are dependent upon a number of mechanical factors. One of these is the rotary compressor. And, despite their appearance, these big, rugged machines are vulnerable to the billions of tiny abrasive particles found in the air. If the intake air is not thoroughly cleaned *before* it reaches the impellers — minute abrasive dust particles are intercepted by the impeller blades and their abrasive action will quickly wear the blades, resulting in "down time" for repairs.

The AAF MULTI-DUTY filter has proved the solution to this problem. These time-tested units have been performing reliable and economical service in some of the nation's biggest steel mills for years. They remove dust and dirt particles from the intake air before it reaches the impellers. Thus costly replacements and "down time" are minimized and efficiency is maintained when the MULTI-DUTY automatic air filter is on the job. To get the facts about the AAF MULTI-DUTY filter — please write for Engineering Bulletin No. 241.

AAF

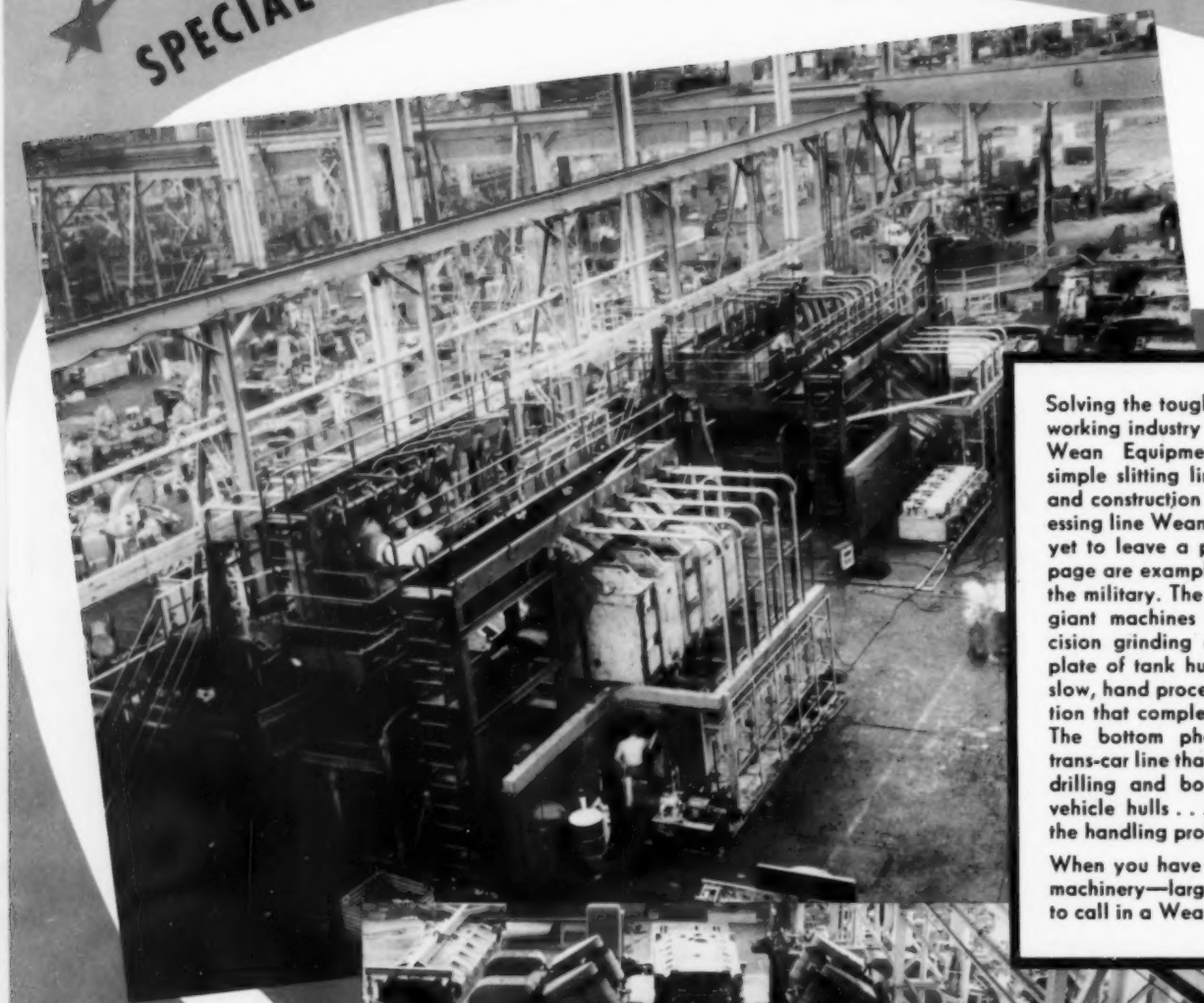
American Air Filter
COMPANY, INC.
302 Central Avenue, Louisville 8, Ky.
American Air Filter of Canada, Ltd., Montreal, P. Q.

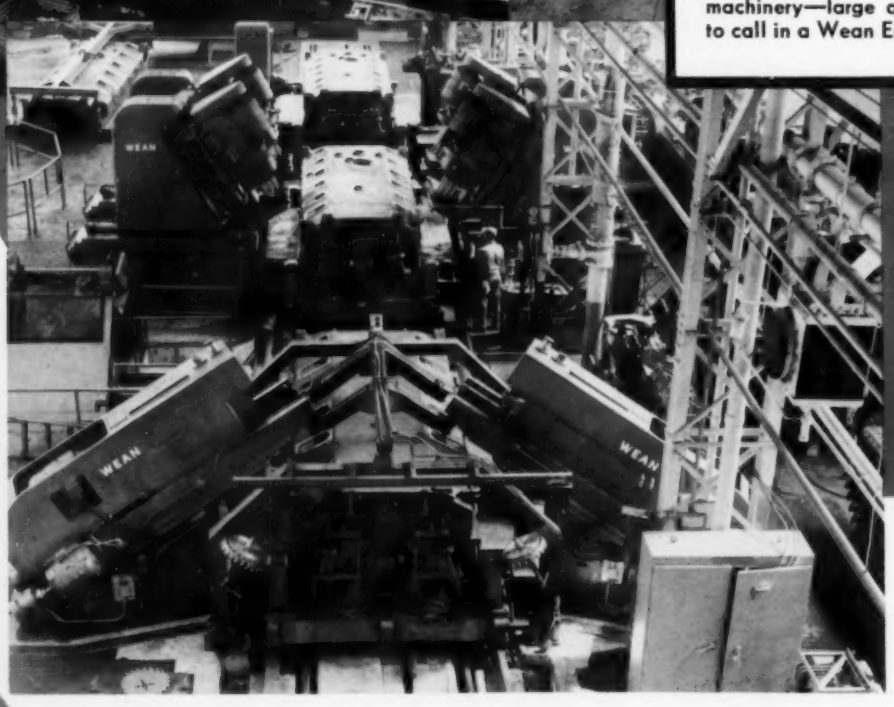
The Wean Engineering Company, Inc., Warren, Ohio is a recognized specialist in the design and installation of sheet, tin and strip mill equipment. The expert knowledge and trained imagination of one of the world's most noted steel mill engineering firms are at your service when you specify Wean — whether the job calls for a single piece of equipment or a complete design of an entire line.

Exit end of high speed tinning line.

The WEAN ENGINEERING COMPANY, Inc.
WARREN OHIO

SPECIAL METAL WORKING EQUIPMENT...





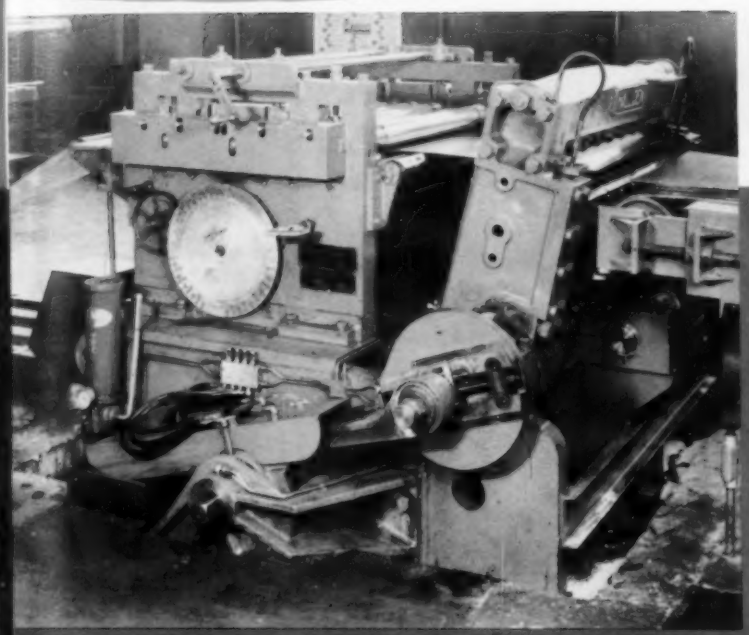
Solving the tougher problems for the metals working industry has become habit with the Wean Equipment Corporation. From a simple slitting line to the complete design and construction of a military vehicle processing line Wean Equipment engineers have yet to leave a problem unsolved. On this page are examples of recent Wean jobs for the military. The top photograph shows two giant machines designed to perform precision grinding and drilling on the armor plate of tank hulls. The machines turned a slow, hand process into a production operation that completes the job 22 times faster. The bottom photograph is of a unique trans-car line that performs precision milling, drilling and boring operations on heavy vehicle hulls . . . at the same time solving the handling problem of these bulky pieces.

When you have a job that requires special machinery—large or small—you'll be wise to call in a Wean Equipment engineer.

MACHINERY TODAY IS THE BUSINESS OF THE

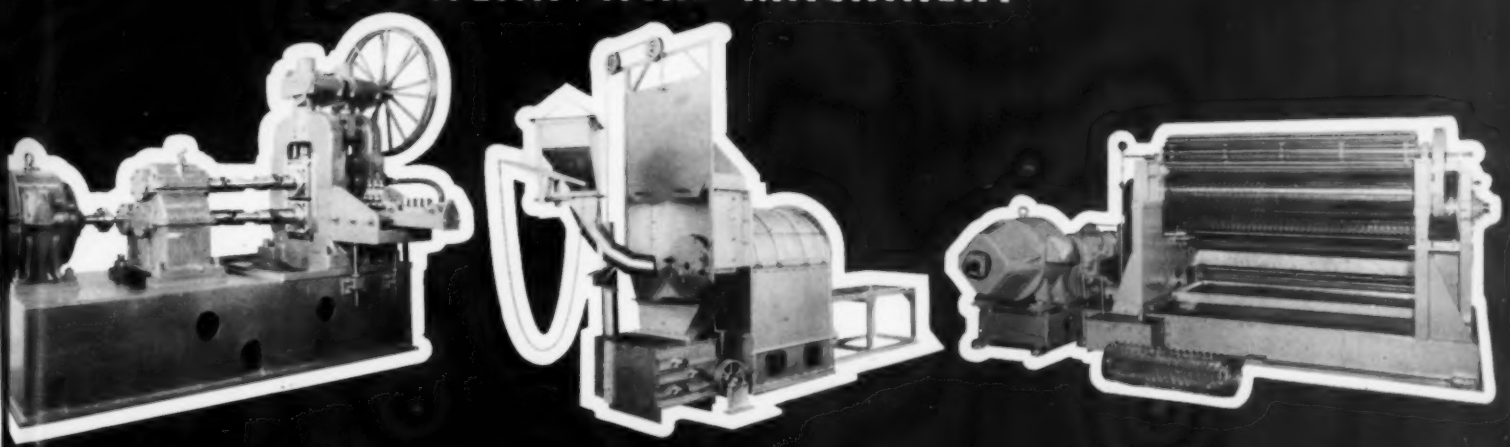
EQUIPMENT CORPORATION
Wean
Cleveland, Ohio

WEAN ADVANCED SLITTING and FLYING SHEAR LINE...



Here's the most advanced flying shear line marketed today. A line that can save you up to 20 per cent on your steel costs because it can make 100 cuts-per-minute to resquared tolerances. If you are a user of sheet steel it will more than pay you to get in touch with a Wean Equipment engineer and have him prove to you how you can order your steel direct from the mill, in coil form, eliminate expensive extras, and make a saving amounting to almost $20 per ton in your final steel costs. You can't afford to overlook this amazing new line . . . get in touch with Wean Equipment in Cleveland, Chicago or Detroit.

WEAN WIRE MACHINERY



n Equipment has for years been the
r producer of wire machinery, and has
"know-how" to design and build ma-
s to speed wire production and proc-

essing all along the line. If you make wire or wire products you should know the Wean Equipment man in your area. Products pictured here are typical of Wean wire machinery; a 2-hi wire flattening mill, a nail galvanizing unit, and a hexagon netting machine that holds all records for the manufacture of this popular wire product.

Wean high speed electrolytic cleaning line.

WEAN
ENGINEERING
Company, Inc.
WARREN, OHIO

ASSOCIATE COMPANIES

Wean Equipment Corporation.....Cleveland, Ohio
The McKay Machine Company.....Youngstown, Ohio
Flinn & Dreffein Engineering Co.....Chicago, Illinois
The Halldon Machine Company.....Thomaston, Connecticut
The Drever Company.....Philadelphia, Pennsylvania
The Wean Engineering Co. of Canada, Ltd....Hamilton, Ontario

REPRESENTATIVES

ENGLAND
John Miles & Partner (London, Ltd.).....London, England

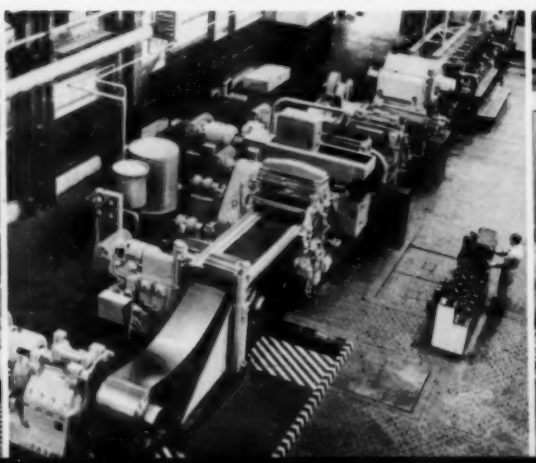
FRANCE
P. Damiron & Company.....Paris, France

ITALY
Norvil Company.....Milan, Italy

JAPAN
Okura & Company.....Tokyo, Japan

Continuous strip pickle line

Continuous electrolytic cleaning line



Continuous coating line

this TSP* DRUM has saved $6501.50 on cables alone, and savings are continuing to mount

Final cable savings will not be known until this TSP Drum is completely worn out. Even after three times the life of previous competitive drums, there are no signs of wear, as shown in our "Industry Report"

Here's why—Ordinary drums have soft groove surfaces. They develop wear, corrugating and chafing. This means short cable life with resultant cable cost, downtime cost, etc.

TSP Drums are file hard. The hardened grooves are smooth and true and they stay that way for years. Any side swinging of loads has no effect on TSP drum grooves.

Due to TSP drums' hardened wear resistant surfaces, all chafing of cable is eliminated. Customer records show cable life extended three times with resultant large saving in cable costs.

INDUSTRY REPORTS

TSP Drum installed on 15 ton Morgan Crane at large Southern Ohio Steel Mill

SERVICE RECORD

TSP DRUM	COMPETITIVE DRUM
86 months service and still in operation with grooves smooth, showing no signs of wear.	26 months service and taken out of operation with grooves rough and worn with sharp edges not suitable for use.
25 days average cable life on a TSP drum.	8 days average cable life on competitive drum.

*TOOL STEEL PROCESS PRODUCTS . . . the products that carry an absolutely positive GUARANTEE to give a longer life in the same service than any other product.

THE TOOL STEEL GEAR AND PINION CO.
CINCINNATI 16, OHIO, U. S. A.

AD-56

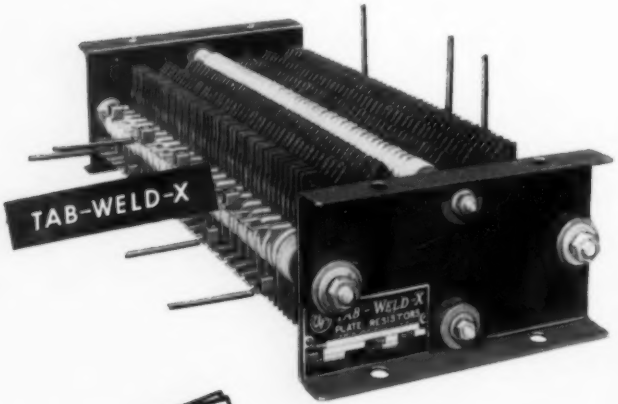
THE STANDARD OF QUALITY SINCE 1900 FOR GEARS • PINIONS • ROLLS • WHEELS AND OTHER MACHINE

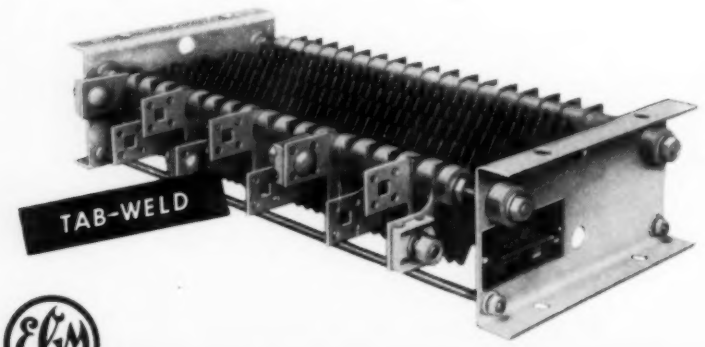
low priced yet...it includes Preventive Maintenance

"F. O. B." *(FREE-OF-BURNING)*

Resistors get little attention, because they are usually mounted overhead or in similar hard-to-reach locations. Clamping-nut pressure slackens under alternate heating and cooling. Formerly, under the reduced pressure, OHMIC value changed, burning occurred and often was *not* noticed until damage took its toll.

But — note how resistor troubles are now eliminated in the EC&M TAB-WELD design! The current-carrying path is continuous — and is ***independent*** of end clamping-nut pressure. Convenient tap-plates simplify tap-shifting—make possible small adjustments in resistance value, because plates are closely spaced. Also, these alloy-steel resistors are corrosion-resisting—and have negligible resistance-change between cold and maximum working temperatures.

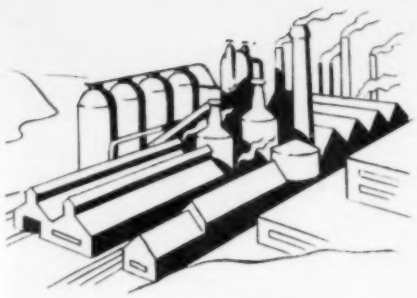




SPECIFY BULLETIN 942 EC&M Welded Plate Resistors

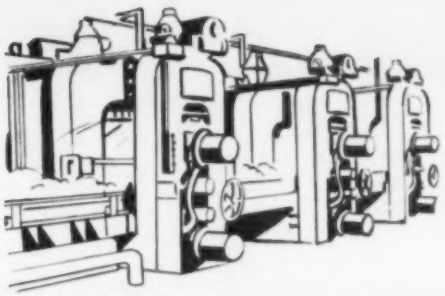
E C & M

THE ELECTRIC CONTROLLER & MFG. CO.
2698 EAST 79TH STREET • CLEVELAND 4, OHIO

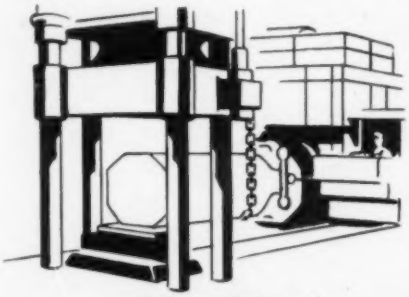


Steel Producing Plants

WHEN A *REGULAR LUBRICANT* ISN'T GOOD ENOUGH . . .



Hot Strip, Cold Reduction and Temper Pass Mills



Forging Industries

SPECIFY LEADOLENE* *Klingfast*

CHECK THESE 9 IMPORTANT FACTS:

1. **EXTREME PRESSURE pH-ilm STRENGTH** of 50,000 lbs. per square inch minimum by "Timken" testing machine.
2. **ADHESIVENESS** in which affinity for steel and other metals develops maximum adhesion and prevents drippage or creeping. Retains a flexible coating in nature.
3. **WATER REPELLENCE** which retards washing off, creates a lubricating pH-ilm under moisture or water conditions.
4. **CORROSION PREVENTION** is an excellent protective coating in that it will not etch or corrode metals. Is never acidic.
5. **COMPOUNDED STABILITY**—Will not bleed or change physical condition within range of higher than usual temperatures for this type of lubricant.
6. **LOW TEMPERATURE FACTORS**—While having a solidifying action by decreased temperature as low as —40 F., it does not harden, crack or decrease in adhesion. The flexible coating withstands distortion of the application.
7. **ABRASIVE RESISTANCE**—Extremely high for a lubricant. Does not wipe off nor will be removed in handling by workmen's hands or gloves. Is extremely repellent to adhesion of scale, metallics and other forms of dusts or contamination.
8. Klingfast has remarkable corrosive resistance to salt or sea water, acidic vapors and solutions.
9. Klingfast can be removed by ordinary solvents such as kerosene, gasolene, naphtha, carbontetrachloride and similar substances but is highly impervious to lubricating oils and greases.

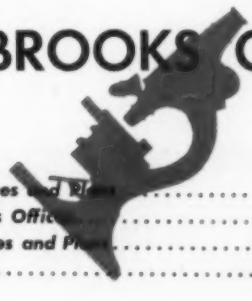
The "I.P." LUBRICANT*

On the really tough jobs in the steel industry, the answer to vastly reduced lubricating costs and extended equipment life is *Leadolene Klingfast.* Capable of withstanding pressures up to 50,000 p.s.i., this lead-base lubricant with its "indestructible pH-ilm" has proved itself repeatedly on the most difficult applications.

For efficient lubrication in the presence of water . . . for extreme adhesiveness to steel under high heat conditions . . . for unexcelled abrasion and corrosion-resistance . . . for actual cash savings up to 400 per cent—investigate the performance characteristics of *Leadolene Klingfast.*

*I. P. . . . ("Indestructible pH-ilm" lubricant)

Write for 24-page descriptive booklet

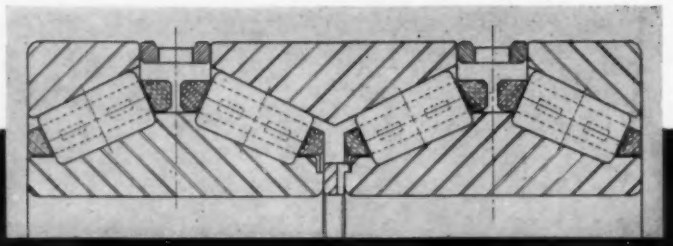


THE BROOKS OIL CO.

Since 1876

Executive Offices ..... **Cleveland, Ohio**
Executive Sales Offices ..... **Pittsburgh, Pa.**
Canadian Offices and Plant ..... **Hamilton, Ontario**
Cuban Office ..... **Santiago de Cuba**

TORRINGTON Four-Row Tapered Roller Bearings on finishing-stand work-rolls of U. S. Steel 80" hot-strip mill were specially designed for high thrust loads.



Rolling to a new

world's record!

2,621,500 net tons of 2000-foot coils of uniform strip! That was the world's record rolled in 1951 by U. S. Steel's 80" hot-strip mill—on TORRINGTON Tapered Roller Bearings.

Precision-ground TORRINGTON Tapered Roller Bearings are used on many of the work-roll and back-up thrust positions, from the huge mill's No. 1 scale breaker to its finishing stands.

These TORRINGTON Bearings, say U. S. Steel engineers, have given excellent service. Specially designed by TORRINGTON to withstand the high thrust loads developed, they have helped to cut down-time to only one hour a turn.

Get more tons per turn from *your* mills. Equip them with TORRINGTON Tapered Roller Bearings.

THE TORRINGTON COMPANY

South Bend 21, Ind. Torrington, Conn.

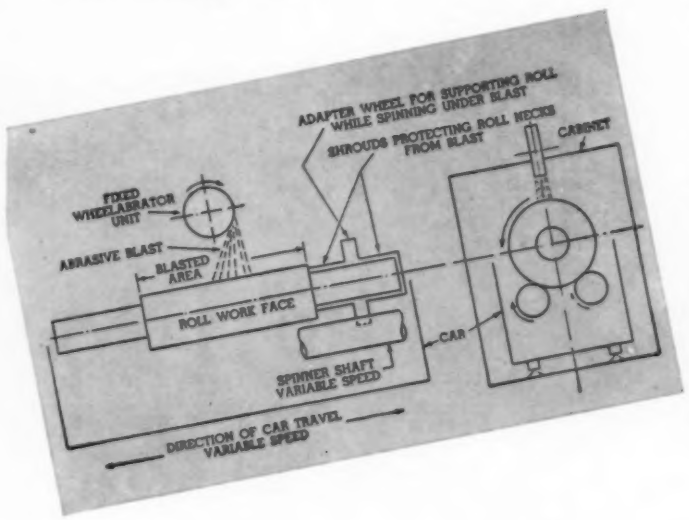
TORRINGTON TAPERED ROLLER **BEARINGS**

Spherical Roller • Needle • Tapered Roller • Straight Roller • Ball • Needle Rollers

NEW SAVINGS for the steel industry

Etching mill rolls with the Airless WHEELABRATOR®

The Wheelabrator opens new horizons in cost-savings possibilities for steel mills in the etching of mill rolls used in temper mills. In a typical installation at the Weirton Steel Company, 8 to 9 inch diameter rolls are etched in just 54 seconds blasting time. Large 26 and 27 inch diameter rolls used in the cold mill, are etched in 3 minutes blasting time.



The diagram shows the airless Wheelabrator method of roll etching. This exclusive development conveys and rotates the work under a fixed and constant rectangular blast from the wheel.

PAYS FOR ITSELF THROUGH SAVINGS

Weirton previously roughened its temper mill rolls by passing emery paper between the rolls after installation in the mill. By eliminating use of emery paper for the initial etching of ground rolls, the Wheelabrator will more than pay for itself through savings in the cost of paper alone. Another big advantage is that it provides a better shape to the roll which means better gripping in the mill. Wheelabrating also provides an etch of a more uniform depth and texture which insures an improved surface on the steel sheet.

AN IMPROVEMENT OVER AIRBLASTING

The Wheelabrator roughens mill rolls in 1 to 3 minutes that commonly takes from 10 to 30 minutes in conventional airblast machines. It produces a uniform etch automatically at a greatly reduced cost per roll. It is a proved fact that rolls so etched have a materially increased life in the mill with a resulting increase in tons rolled per set of rolls.

Write today for complete information.

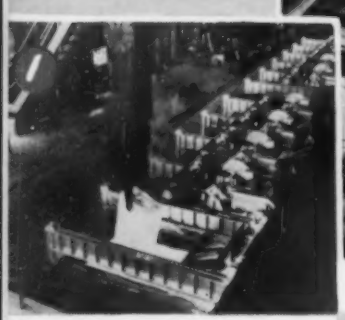
American
WHEELABRATOR & EQUIPMENT CORP.
396 S. Byrkit St., Mishawaka, Ind.

Wheelabrator®
AIRLESS BLAST CLEANING

D-3575

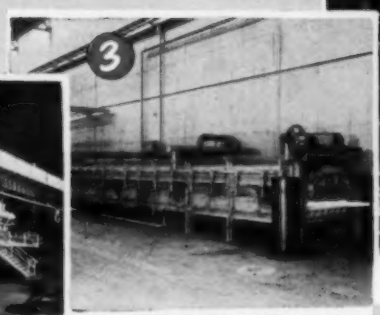
WORLD'S LARGEST BUILDERS OF AIRLESS BLAST EQUIPMENT

from INGOT to FINISHED PRODUCT

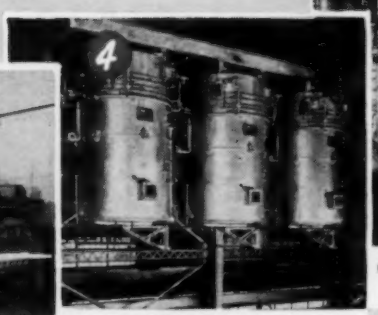


One-way fired
recuperative soaking pits.

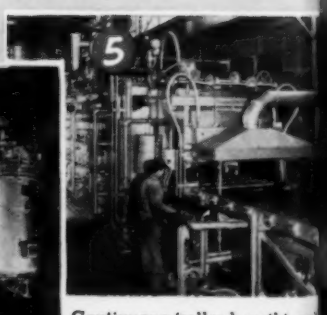
Continuous triple-fired
slab and billet furnace.



Continuous wire
patenting furnace.



Pit type rod
annealing furnace.

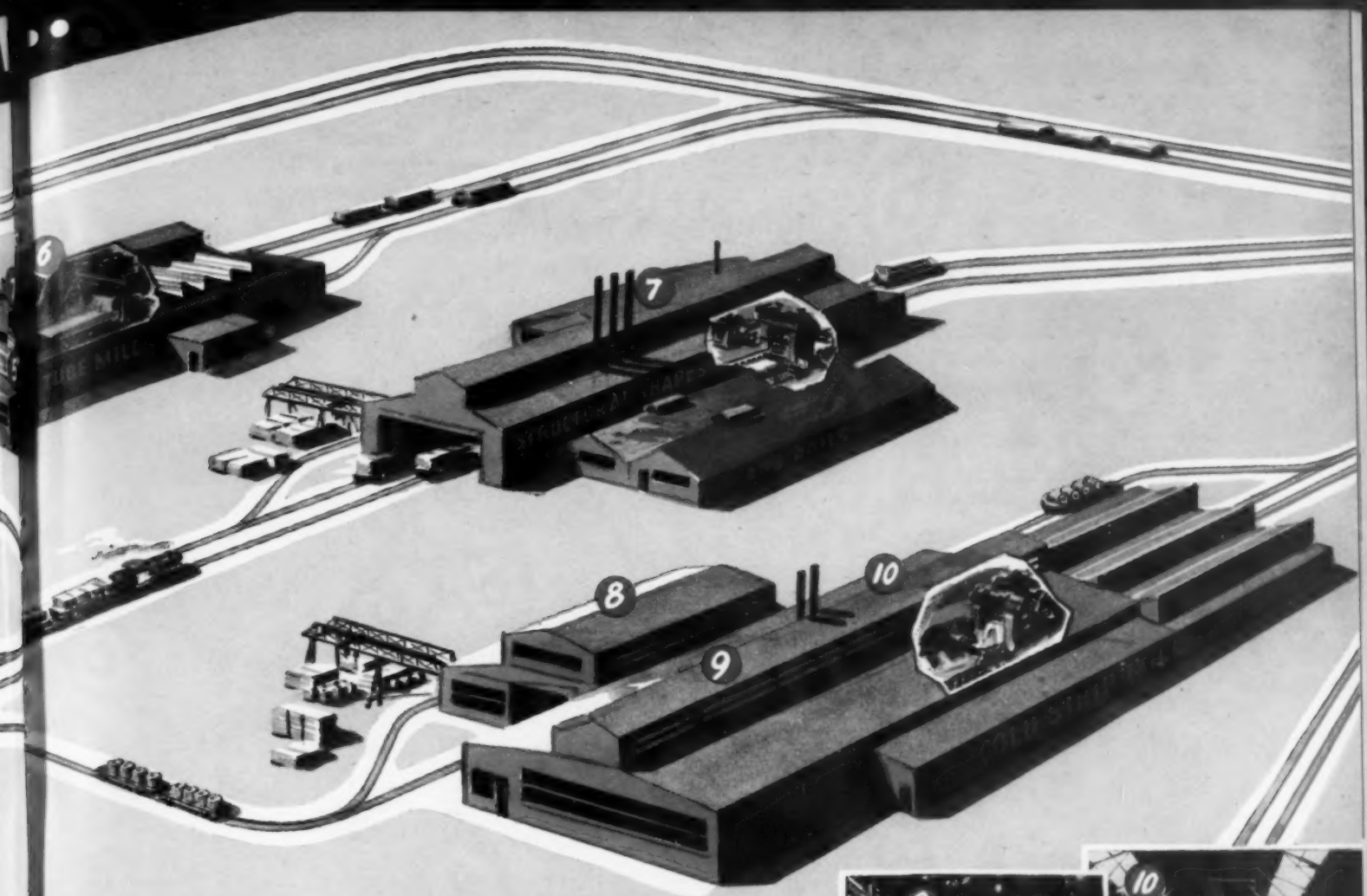


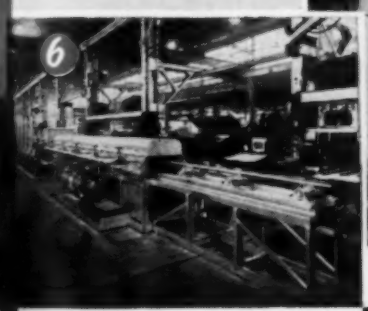
Continuous (roller hearth) car
restoration annealing furnace

Surface

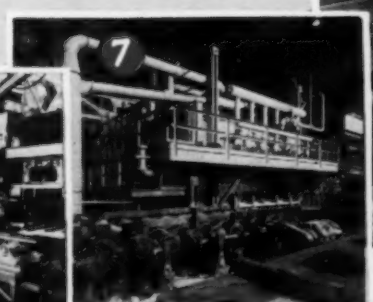
SERVES THE STEEL INDUSTRY

SURFACE COMBUSTION CORPORATION, TOLEDO, OHIO



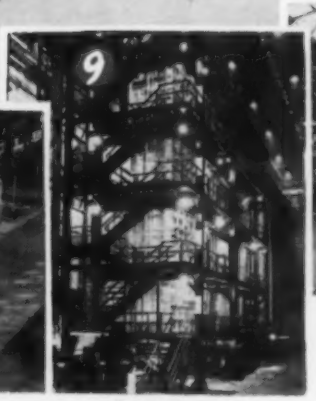


High-speed stress relief furnace for steel tubing.



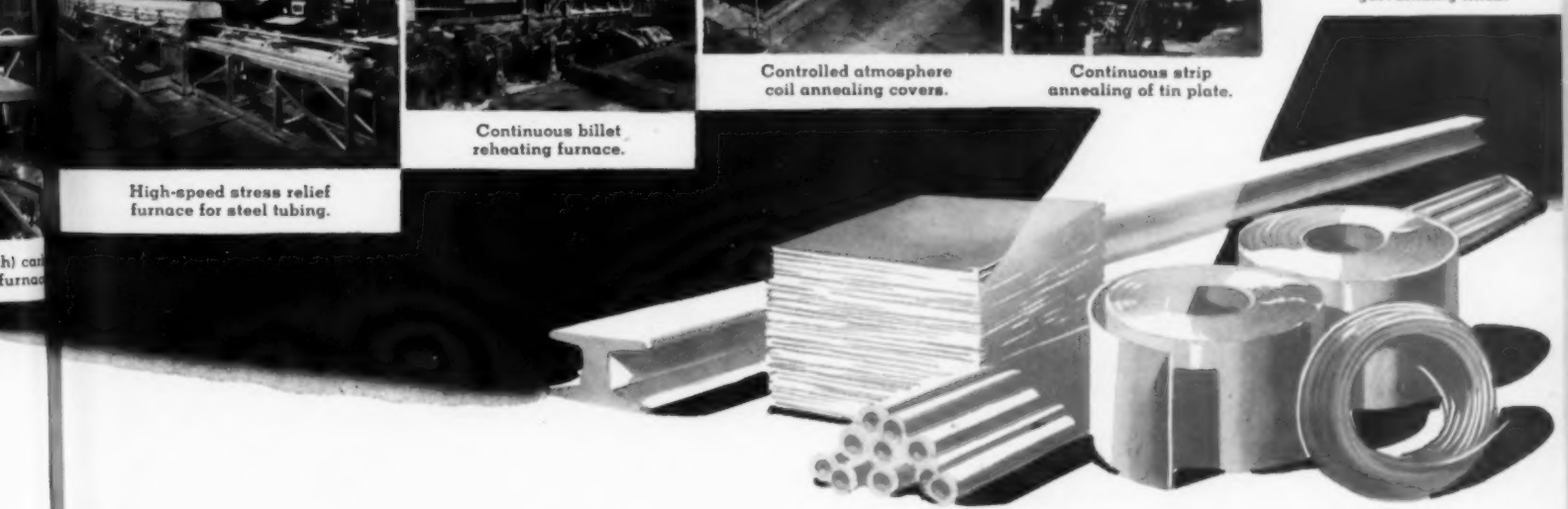
Continuous billet reheating furnace.

Controlled atmosphere coil annealing covers.



Continuous strip annealing of tin plate.

Continuous strip galvanizing lines.



. . . IN HUNDREDS OF SUCCESSFUL INSTALLATIONS, IS LIVING UP TO ITS REPUTATION FOR BIG TONNAGE . . . END RESULTS OF THE HIGHEST QUALITY...DEPENDABLE PERFORMANCE SECOND TO NONE!

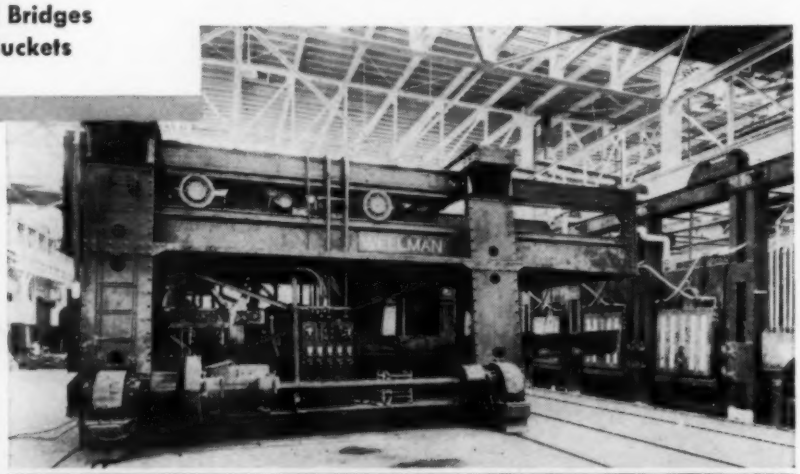
"A GREAT PRODUCTION NAME IN THE STEEL INDUSTRY"

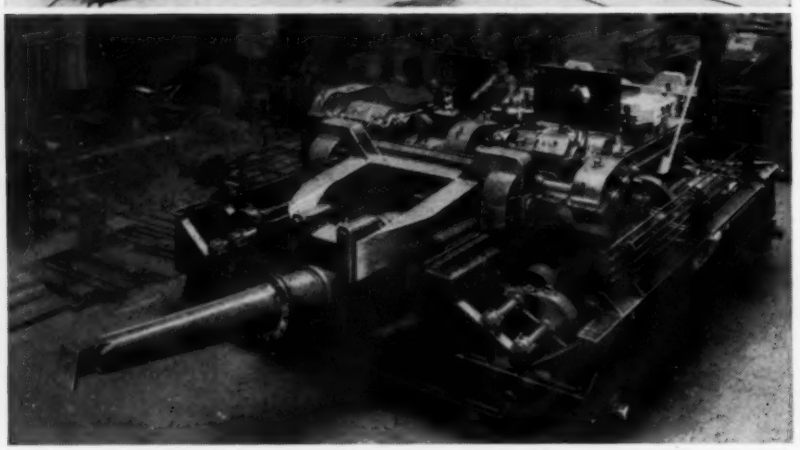
Wellman will build it

Special Cranes
Charging Machines
Ore Unloaders
Forging Manipulators
Car Dumpers
Gas Flue Systems
Gas Reversing Valves
Coke Pushers
Mine Hoists
Skip Hoists
Ore and Coal Bridges
Clamshell Buckets

→ Wellman charging machines

efficiently serve open-hearth furnaces





Above:
Wellman High-Type, Open-Hearth Charging Machine.

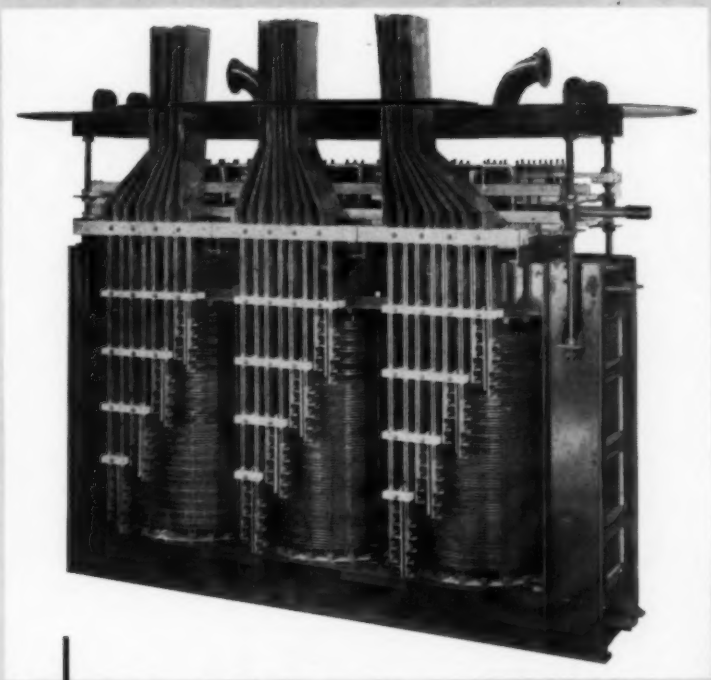
Below:
Wellman Low-Type Charging Machine.

● Wellman Charging Machines for open-hearth furnaces are available in the high-type shown above and in low-type shown in inset. These machines are typical of all Wellman equipment. They are backed by more than a half-century of experience in designing and building for efficient performance. You can have utmost confidence in Wellman recommendations.

THE WELLMAN ENGINEERING COMPANY

7000 CENTRAL AVENUE · CLEVELAND 4, OHIO

100 kva... 25,000 kva...or higher...



25,000 Kva Furnace Transformer, Low Voltage Side. 3 Phase, 60 Cycles, Water-cooled. High Voltage: 13800 volts. Low Voltage: 430 to 290 volts.

Pennsylvania can build a Furnace Transformer for any size electric furnace

External view of transformer. Compartment on left houses motor-operated tap changer.

The successful operation of Pennsylvania Furnace Transformers and their industry-wide acceptance indicate that Pennsylvania engineers fully understand the application of furnace transformers to electric furnaces.

For example, in 1936 Pennsylvania introduced a new type of helical winding in the low voltage coils of a 2500 Kva furnace transformer. Since then, the same principles of coil design have been incorporated into Pennsylvania furnace transformers totaling over $1\frac{1}{4}$ million Kva. In all the intervening years, there has *never* been a low voltage winding breakdown on any of these furnace transformers.

Because its engineering is basically and fundamentally correct, Pennsylvania can build furnace transformers for any size electric furnace now being manufactured or being contemplated for future construction.

Pennsylvania TRANSFORMERS

Furnace Transformer Experts

Pennsylvania TRANSFORMER COMPANY

CANONSBURG, PENNSYLVANIA

Greater Pittsburgh District

Application engineering . . . *essential to control*

No matter what the product, every plant uses methods, materials and equipment that present problems peculiar to its own production. Specifications . . . size of plant . . . rate of output . . . all impose further unique restrictions.

What, then, about process control instrumentation? To do its job right, it has to be designed with all those factors . . . and many others . . . in mind. And here is where Honeywell Application Engineering steps in.

First comes a thorough investigation of control requirements. A Honeywell engineering representative, well versed in instrumentation techniques sits down with process engineers, production men, and instrument technicians . . . discusses details of the specific process. Then he puts the problem up to Honeywell's staff of application engineers.

Specialists for Each Industry

In this group are men who are expert in each specific industry. One group, for example, specializes in instrumentation for the metalworking industry . . . another for chemical . . . another for petroleum . . . until the whole gamut of modern manufacturing is represented. Each man has been trained, by education and first-hand experience, in the techniques of processing and process control in the area of his interest. Each is a living part of the industry he serves. And he knows why and where every process "is different."

Covers All Aspects of Control

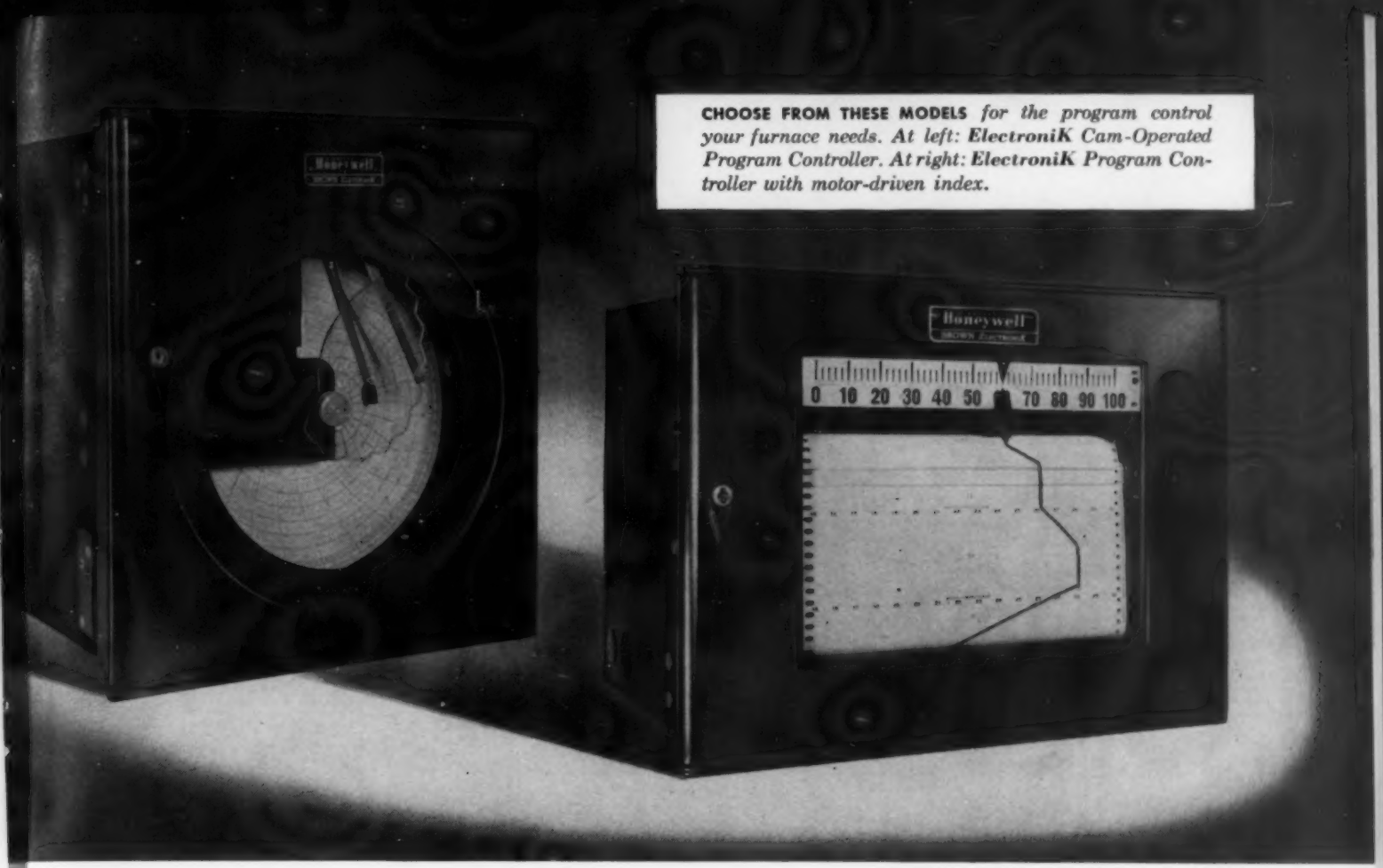
Honeywell application engineering covers the entire control installation. It works out details of what instrument to use for each measurement or control function . . . what type of primary element . . . what control system . . . what size and style of valve. It provides all essential signals, safety interlocks, and accessories. It combines all these elements into a complete unit, arranged for peak production efficiency . . . greatest convenience of the operator, and for maximum ease of service . . . custom-fitted to the individual needs of the process to be controlled.

Saves Time . . . Produces Top Performance

This Honeywell service gives specialized consultation on complex control problems that would otherwise require the attention of experts in the individual plant. But most important, it assures a control system that will produce the superior performance that Honeywell instruments are capable of giving . . . and which will help to obtain the most production and best quality from the process which it serves.

Flexible *for any*

SOUND PLANNING, *based on specialized engineering experience, forms the basis of Honeywell Application Engineering. Here a round-table discussion between customer and Honeywell technicians irons out the initial control requirements for a process.*



CHOOSE FROM THESE MODELS *for the program control your furnace needs. At left:* ***ElectroniK*** *Cam-Operated Program Controller. At right:* ***ElectroniK*** *Program Controller with motor-driven index.*

automatic control
time-temperature program

ElectroniK Program Controllers give you the utmost flexibility in automatic regulation of time-temperature cycles. They save countless man-hours by conducting furnaces through complete heating, soaking and cooling periods . . . without need for human supervision. And they remove the possibility for human error . . . always reproduce even the most complex cycle with consistent, high accuracy.

For frequently repeated cycles, the ***ElectroniK*** cam-operated controller is recommended. The desired cycle is cut on a calibrated disc of clear plastic. Entire program is visible at all times . . . can be changed simply by replacing the cam.

● **REFERENCE DATA: Write for Bulletins 1501 and 1502.**

For greatest flexibility, the ***ElectroniK*** strip chart controller with motor-driven index provides an infinite variety of programs. Calibrated dials permit choice of heating rates, cooling rates, and soaking periods. An ideal instrument for furnaces which handle a variety of heat-treating cycles.

Available control systems include electric and pneumatic types, applicable to fuel-fired and electric furnaces. For a discussion of how program control can be applied to your own heating process, call your nearest Honeywell engineering representative . . . he is as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 4464 Wayne Ave., Phila. 44, Pa.

MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS
First in Controls

CLEVELAND CRANES

MODERN ALL-WELDED STEEL MILL CRANES

5031 EAST 289th ST.
WICKLIFFE, OHIO

Crops and Shorts

A recent interim report issued by the Defense Production Administration and the National Production Authority gives a break-down of steel expansion expenditures, which shows that, as of last October, necessity certificates had been issued for projects costing about $4,660,000,000, of which $3,100,000,000 was given rapid amortization privileges. Of the total expenditure, $1,784,000,000 was for raw material facilities, $1,610,000,000 for blast furnaces and steel making furnaces, and $1,265,000,000 for rolling mills, etc. Of the rolling mill figure, facilities for sheet and strip production made up $714,000,000, or about 15 per cent of the total expenditure.

The report further stated that no target had been set as to how much steel of the various kinds would be needed in case of war. It was not known whether the expanded facilities would meet these unknown demands.

Nevertheless, when the report was reviewed in the newspapers (probably from releases sent out by the government agencies), the emphasis was placed on the fact that two-thirds of the tax-aided expansion of steel industry finishing facilities was going into equipment to turn out light steel products used in civilian hard goods and only one-third into facilities for heavy steel products. The facts that 85 per cent of the total expenditure was for basic capacity expansion, and that a major portion of the other 15 per cent was readily convertible to the production of important armament items were completely overlooked.

This is just another instance of the prevalent practice of giving out the impression of treasonable knavery on the part of industry.

▲

WHILE much of the blame for incidents such as the foregoing must be laid to biased public relations men, the newspapers themselves are not completely guiltless. Frequently, the desire to make headlines leads to hasty or unfounded conclusions. The recent turmoil as to whether or not a Korean raid was a legitimate military operation or a planned exhibition is another example of what poorly considered publicity and headline seeking can do.

Newsmen, who insist that the public must be informed and who vociferously champion the freedom of the press must remember that freedom entails responsibility.

▲

THE iron and steel industry spent $1,170,000,000, a record high, to expand and improve its plants during1952, according to the American Iron and Steel Institute. At the same time, annual steel capacity made its largest yearly jump, rising nearly 9,000,000 tons to a new high of 117,500,000 tons.

Industry plans call for 1953 expenditures totaling about $1,000,000,000, with the addition of another 4,000,000 tons to the annual capacity.

▲

AND to remain with new records, employment in the iron and steel industry was higher in November than ever before at an estimated 680,300 persons, with average hourly earnings of wage earners also at a record $2.218.

▲

OUR federal government now owns 24 per cent of all the land within the continental limits of the United States, ranging from nearly 85 per cent of Nevada down to .3 per cent of Iowa. The department of the Interior is the largest shareholder, with 262,000,000 acres. Second is the department of Agriculture, with 168,000,000 acres. During the past 30 years, 45,000,000 acres have been taken from private owners.

As pointed out recently by Admiral Ben Moreell, chairman of Jones & Laughlin Steel Corp., government ownership of land is the first plank in the communist platform.

▲

STAINLESS steel formed .97 per cent of the total steel production in 1952. This proportion has increased almost every year since the early thirties. Stainless tonnage in 1952 was 901,831 net tons, nearly 12 times that of 1935.

▲

IF Washington stops taking the shirts off our backs, maybe they won't need all those bureaus down there to keep them in.

▲

A paper presented before the annual ASME meeting by Frederic O. Hess, of Selas Corp. of America, quoted industrial fuel consumptions in the United States as follows:

	1938	1950
Bituminous coal (including coking coal), net tons	158,000,000	224,000,000
Electric power, million kwhr	62,700	189,500
Fuel oil, barrels	60,000,000	185,000,000
Gas, million therms	7,941	22,886

▲

LUKENS Steel Co. is setting up a "speakers bureau," composed of 20 to 30 company men who will be available without charge to civic and service clubs, church groups, schools, etc. Topics will cover a wide range of general interest, with the objective of increasing public understanding of the steel industry on local and national levels.

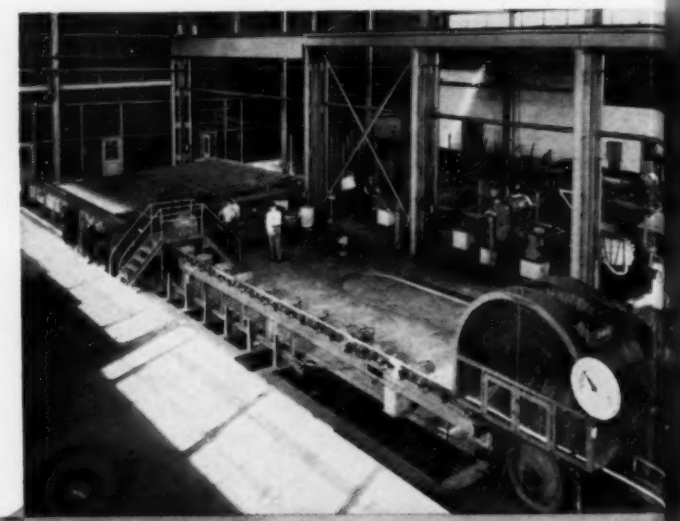
▲

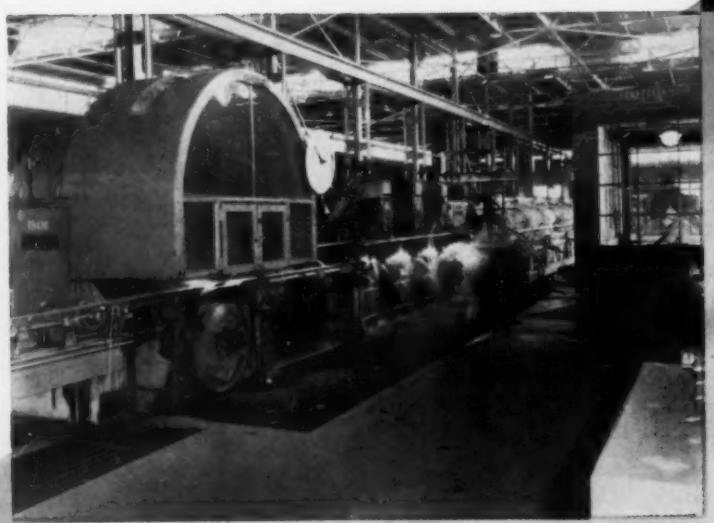
FROM the Wall Street Journal: "Most men look older than their age from working so hard to keep their wives looking younger than theirs."

NEWEST

continuous butt weld

DESIGNED, BUILT AND INSTALLED BY AETNA-STANDARD FOR SHARON TUBE





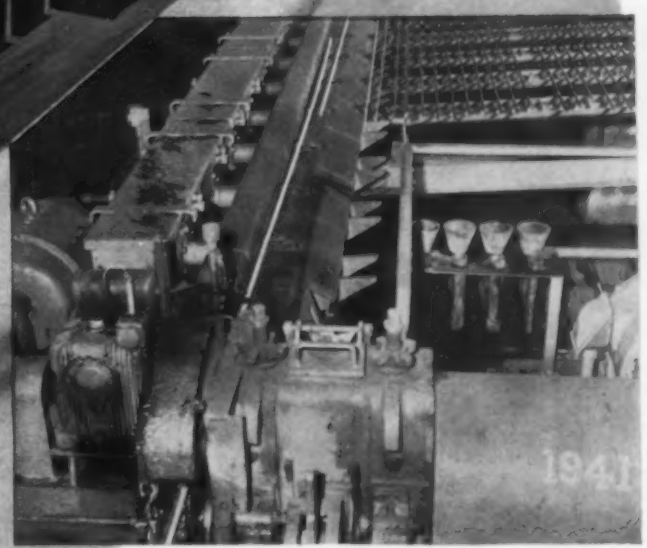
The Rotary Hot Saw (lower right) cuts pipe into specified lengths between 18 and 22 feet. Lengths then pass through sizing mill to Screw Type Cooling Bed (upper left).

Looking toward the furnace end with Rotary Hot Saw in foreground and 8-Stand Forming and Welding Mill. Control house on right.

- Rated at 700 feet per minute.
- Size range — ⅛" to ¾".
- Actual production run — 191,225 feet (40 miles) of ¼" pipe in five hours.
- Rotary Flying Hot Saw cuts to pre-determined lengths between 18 and 22 feet.
- Sizing Mill in direct line with Forming and Welding Mill.
- New Type Rotary Kick-Off handles 75 lengths of pipe per minute.
- Screw Type Cooling Bed aids in straightening pipe.
- In addition to mill, Aetna-Standard's responsibility included the designing and building of the entire plant from ground up.

Designers and Builders of Pipe and Tube Mills...

pipe mill



Here's Sharon Tube's new 700 foot per minute Continuous Butt Weld Pipe Mill with Sizing Mill in foreground. Photo on right shows new type rotary kick-off which can handle 75 lengths per minute.

Aetna-Standard

THE AETNA-STANDARD ENGINEERING COMPANY · PITTSBURGH, PA.

Plants in Warren, Ohio · Ellwood City, Pennsylvania

ASSOCIATED COMPANIES

Head Wrightson Machine Company, Ltd., Middlesbrough, England—Great Britain, Finland, Sweden, Norway, Denmark, Union of South Africa, Northern and Southern Rhodesia.

Aetna-Standard Engineering Company, Ltd., Toronto, Ontario, Canada.

M. Castellvi, Inc., New York, N. Y.—Mexico, Central and South America.

Societe de Constructions de Montbard, Paris, France—France, Belgium, Holland, Luxembourg, Switzerland.

Demag Aktiengesellschaft, Duisburg, Germany—Germany, Austria, Yugoslavia, Greece, Turkey, Egypt.

Compagnia Italiana Forme Acciaio, Milano, Italy—Italy.

Aetna-Japan Company, Ltd., Tokyo, Japan—Japan.

Hale & Kullgren, Inc., Akron, Ohio—Representative for the Rubber Industry.

Designers and Builders to the Ferrous, Non-Ferrous, Leather and Rubber Industries

Rolls tubing to within one-half standard wall tolerances... *with help of TIMKEN® bearings*

HEAVY-WALL tubing can be rolled to within one-half standard tolerances on Assel type tube mills, developed by the Timken Company and built by Aetna-Standard. This type of mill is one of the most accurate rolling mills ever built for mechanical tubing.

One big reason for the mill's extreme accuracy is the Timken® tapered roller bearings on the roll necks of the three rolls.

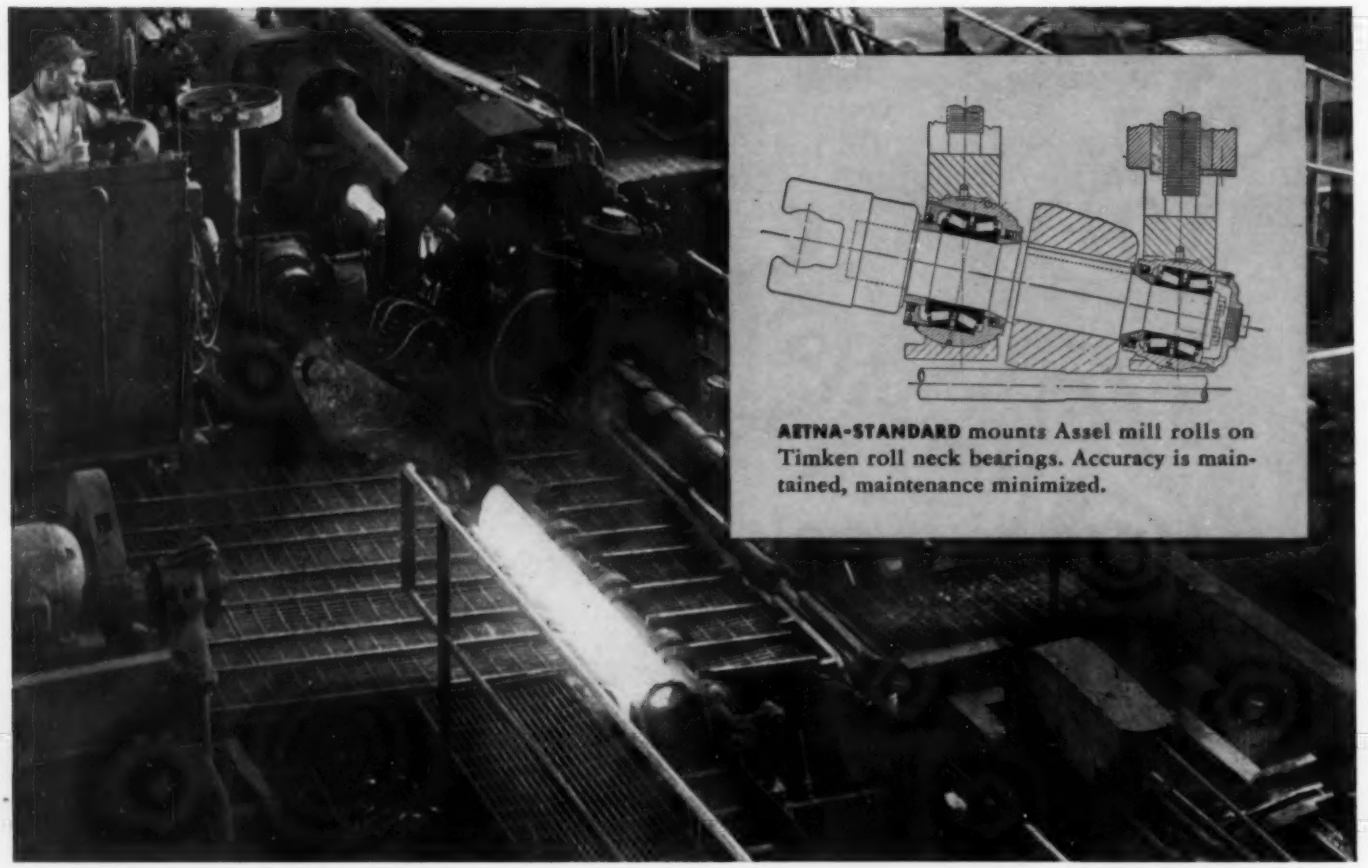
Timken roll neck bearings take radial, thrust and combination loads without special thrust units. Chuck mountings are simpler and more compact. Greater mill rigidity is provided because Timken bearings permit larger diameter roll necks. Load ratings are increased as much as 40%. Roll neck strength is increased 50 to 60%.

Friction within the Timken bearing itself is practically eliminated by true rolling motion and incredibly smooth surface finish. And its lower starting resistance permits mills to accelerate more rapidly.

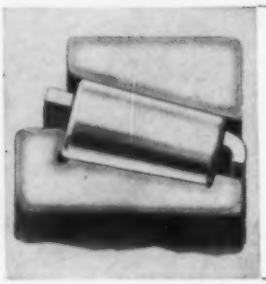
Timken bearings also eliminate complicated lubrication systems, permit the use of simple and economical grease lubrication. No need for pipes or tubes. Rolls can be changed faster.

To get all these advantages in the mill equipment you buy or build, be sure to specify Timken tapered roller bearings. And look for the trade-mark "Timken" stamped on every bearing. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.



AETNA-STANDARD mounts Assel mill rolls on Timken roll neck bearings. Accuracy is maintained, maintenance minimized.



GREATER LOAD AREA

Because the load is carried on the *line* of contact between rollers and races, Timken bearings carry greater loads, hold shafts in line, wear longer.

The Timken Roller Bearing Company is the acknowledged leader in: 1. advanced design; 2. precision manufacturing; 3. rigid quality control; 4. special analysis steels.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

NOT JUST A BALL ○ NOT JUST A ROLLER ⬭ THE TIMKEN TAPERED ROLLER ⬭ BEARING TAKES RADIAL ⬮ AND THRUST → ⬮ ← LOADS OR ANY COMBINATION → ✳ ←

T. J. ESS, *Editor*
I. E. MADSEN, *Associate Editor*
ALBERT W. ERICKSON, JR., *Production Manager*

Board of Directors

PRESIDENT
J. L. YOUNG
Vice President—Engineering
United States Steel Corp.
Pittsburgh, Pa.

FIRST VICE PRESIDENT, E. L. ANDERSON, *Superintendent Electrical Department,* Bethlehem Steel Co., Johnstown, Pa.

SECOND VICE PRESIDENT, JOHN H. VOHR, *General Superintendent,* Gary Steel Works, United States Steel Corp., Gary, Ind.

TREASURER, W. H. COLLISON, *Assistant General Superintendent,* Blast Furnace Division, Great Lakes Steel Corp., Ecorse, Mich.

SECRETARY, J. D. O'ROARK, *Assistant to Manager, Service and Maintenance,* Weirton Steel Co., Weirton, W. Va.

PAST PRESIDENTS: A. S. GLOSSBRENNER, *Vice President Operations,* Youngstown Sheet and Tube Co., Youngstown, Ohio.

I. N. TULL, *Electrical Superintendent,* Republic Steel Corp., Cleveland, Ohio.

HONORARY DIRECTORS: JAMES FARRINGTON, *Special Assistant to Chief Plant Engineer,* Wheeling Steel Corp., Steubenville, Ohio.

C. L. McGRANAHAN, *Technical Assistant to Works Manager,* SOLLAC, Seremange (Moselle), France.

L. F. COFFIN, *Assistant General Manager,* Bethlehem Steel Co., Sparrows Point, Md.

DIRECTOR-AT-LARGE: L. LARSON, *Chief Engineer,* Republic Steel Corp., Cleveland, Ohio.

DIRECTORS: C. G. MARSHALL, *Superintendent of Construction, Engineering — Raw Materials Division,* Tennessee Coal and Iron Division, United States Steel Corp., Fairfield, Ala.

A. M. CAMERON, *Superintendent Rolling Mills,* Atlas Steels Limited, Welland, Canada.

F. A. JOHANTGES, *Electrical Engineer,* International Harvester Co., Wisconsin Steel Works, Chicago, Ill.

W. W. BENTZ, *Superintendent Maintenance,* McDonald and Upper Works, United States Steel Corp., McDonald, Ohio.

ROBERT SERGESON, *Chief Metallurgical Engineer,* Rotary Electric Steel Co., Detroit, Mich.

J. S. MORRIS, *Supervisor of Construction,* Lukens Steel Co., Coatesville, Pa.

EMIL KERN, *Vice President in Charge of Engineering,* Allegheny Ludlum Steel Corp., Brackenridge, Pa.

L. V. BLACK, *Superintendent Electric Department,* Bethlehem Steel Co., Bethlehem, Pa.

E. T. W. BAILEY, *Chief Combustion Engineer,* The Steel Co. of Canada Limited, Hamilton, Canada.

T. M. FAIRCHILD, *Assistant to General Manager,* Franklin Mills, Bethlehem Steel Co., Johnstown, Pa.

D. W. LLOYD, *General Superintendent,* Brier Hill Works, Youngstown Sheet and Tube Co., Youngstown, Ohio.

F. E. ROBINSON, *Assistant Division Engineer,* American Steel and Wire Division, United States Steel Corp., Cleveland, Ohio.

R. A. KRAUS, *Assistant Maintenance Superintendent,* Republic Steel Corp., Chicago, Ill.

Managing Director
T. J. ESS
Empire Building
Pittsburgh, Pa.

Iron AND Steel ENGINEER

FEBRUARY, 1953 VOLUME XXX NUMBER II

In This Issue

Patent Reviews — by Melvin Nord, Patent Attorney, Detroit, Mich..... 33

Rolling of Thin Strip — by M. D. Stone, Manager, Development, United Engineering and Foundry Co., Pittsburgh, Pa..... 61

Automatic Control for Regenerative Soaking Pits — by Griffin L. Isaacs, Assistant to Superintendent, Blooming Mills, United States Steel Corp., Duquesne, Pa..... 75

Effect of Lubricant on Gear Performance — by V. N. Borsoff, Research Engineer and S. S. Sorem, Research Engineer, Shell Development Co., Emeryville, Calif..... 83

Inertia Studies for Modern Mill Drives—by T. B. Montgomery, Engineer-in-Charge, Control Design and J. F. Sellers, Assistant Chief Engineer, Motor and Generator Section, Allis-Chalmers Mfg. Co., Milwaukee, Wisc..... 89

New Breaker Block Designed to Limit Roll Loads — by W. H. Bailey, British Iron & Steel Research Association, London, England..... 99

A New High Temperature Alloy — by M. N. Ornitz, Works Manager, and R. H. English, Chief Metallurgist, National Alloy Steel Division, Blaw-Knox Co., Blawnox, Pa..... 102

Current AISE District Section Meeting Notices..... 118

Induction Stirrer For Arc Furnace — by Eric G. Malmlow, President, Aros Electric Co., New York, N. Y. and Quentin Graham, Vice President, Elliott Co., Ridgway, Pa..... 120

New British Wheel Plant Sets Production Records..... 124

Date-line Diary..... 137

Industry News..... 143

Personnel News..... 161

Publication Service..... 175

Equipment News..... 185

Applications for AISE Membership..... 203

Index to Advertisers..... 209

Published Monthly by
ASSOCIATION OF IRON AND STEEL ENGINEERS
1010 EMPIRE BUILDING
PITTSBURGH 22, PENNSYLVANIA

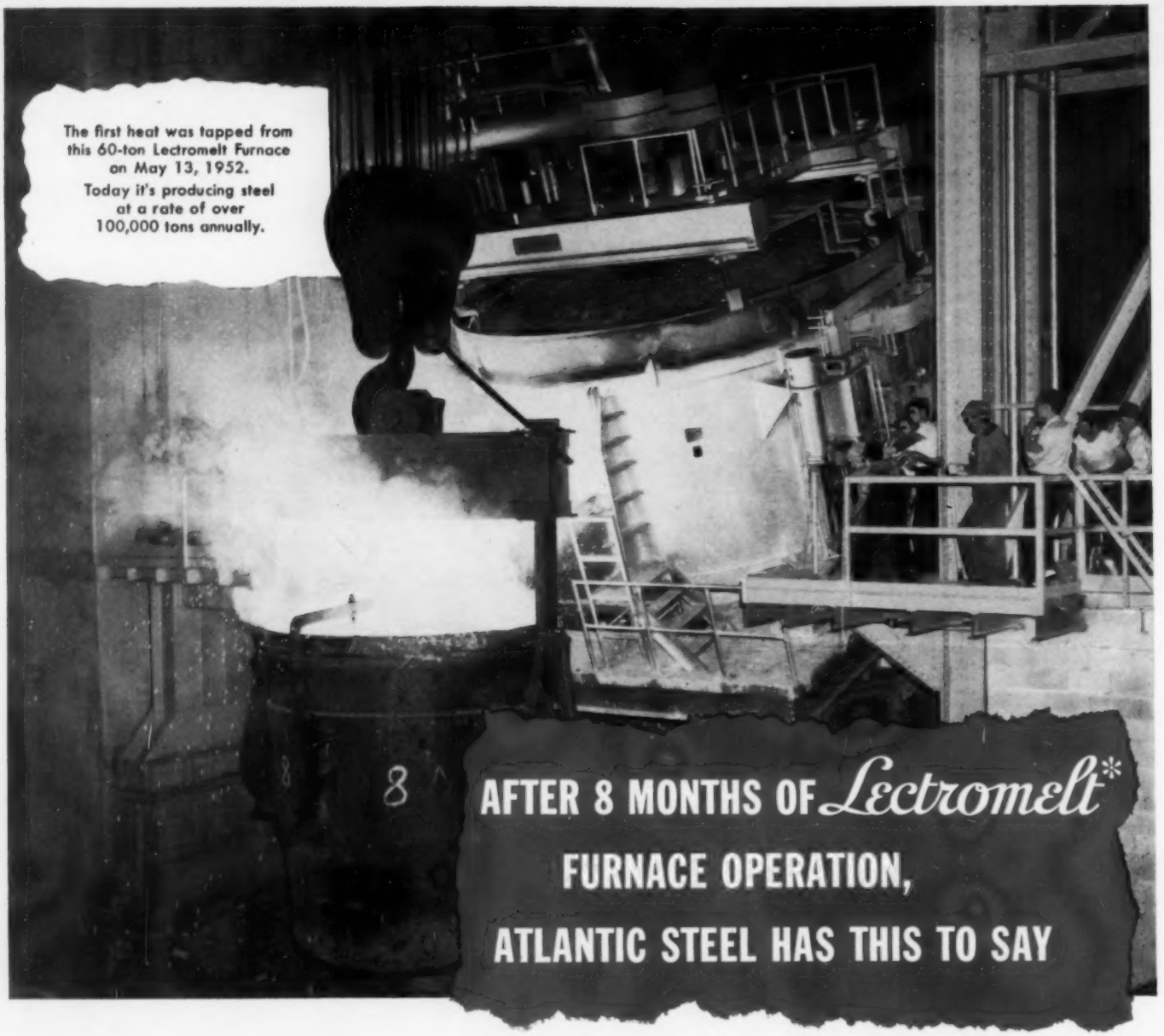
Statements and opinions given in articles and papers appearing in "Iron and Steel Engineer" are the expressions of contributors, for which the Association of Iron and Steel Engineers assumes no responsibility.

Copyright, 1953 The Association of Iron and Steel Engineers.

Indexed by Engineering Index and by Industrial Arts Index.

Single Copy Foreign Prepaid $2.00 Single Copy $1.50
Subscription price in U. S. and Canada (U. S. funds)..... $ 7.50 per year
Subscription price in foreign countries..... $10.00 per year

PLASTIC BINDING U. S. PATENT NO. 1970285 LICENCE NO. 120.


The first heat was tapped from this 60-ton Lectromelt Furnace on May 13, 1952.
Today it's producing steel at a rate of over 100,000 tons annually.
8

AFTER 8 MONTHS OF *Lectromelt** FURNACE OPERATION, ATLANTIC STEEL HAS THIS TO SAY

It's too soon to draw final conclusions, of course, comparing electric furnace operation with our open hearths. Production continues to rise and costs are coming down, as procedures are smoothed out. But we have made these observations:

- Time per heat is about half that required by an open hearth.
- Average down time is much less, even for major repairs. An electric furnace is available 94% of the time.
- Average size of heat 67.12 tons. Yield per ingot is 5% better.
- Metal cost is lower because we don't use pig iron with the electric furnace.
- Fewer man-hours per ton are required.
- After only five months, we got our electric furnace steel costs down below those of our open hearths.

Atlantic Steel Company laid out their plant, from scrap storage yard to pouring pit, around this Lectromelt Furnace. This certainly contributes greatly to these economies. Pittsburgh Lectromelt Furnace Corporation, 310 32nd Street, Pittsburgh 30, Pennsylvania.

Manufactured in . . . CANADA: Lectromelt Furnaces of Canada, Ltd., Toronto 2 . . . ENGLAND: Birlec, Ltd., Birmingham . . . FRANCE: Stein et Roubaix, Paris . . . BELGIUM: S. A. Belge Stein et Roubaix, Bressoux-Liege . . . SPAIN: General Electrica Espanola, Bilbao . . . ITALY: Forni Stein, Genoa.

*REG. T. M. U. S. PAT. OFF.

WHEN YOU MELT... MOORE RAPID *Lectromelt*

Rolling of Thin Strip

By M. D. STONE
Manager, Development
United Engineering and Foundry Co.
Pittsburgh, Pa.

. . . . high speed rolling of thin strip can be most suitably done on four-high mills with small work rolls and driven back-up rolls . . . .

▲ THE cold rolling of thin strip, particularly for hard alloys, such as stainless steel, and the like, is a branch of metal rolling beset both by operational difficulties in carrying out the procedure, as well as by theoretical problems in the prediction of rolling pressures, pass schedules, etc. As is appreciated by those involved in studies of this subject, the importance of factors that are usually ignored when rolling thicker, softer strip, can become paramount for thin hard strip. The importance of these factors has been the subject of many investigations over a period of twenty-five years. In 1941, a study of ours[1]* dealt with these matters in a quantitative manner, and formed the basis for a theory of strip rolling and a calculation procedure that has been used as a design basis for some ten years now.

Let us briefly pick up the salient points of that paper. The earliest fundamental studies of rolling, applicable to thin strip, originated with von Karman in 1925[2], although his work was by-passed for Siebel's[3] for some time. W. Trinks[4], in 1937, appreciating the shortcomings of Siebel's approach to the problem, because of its graphical nature and its failure to take into account the cumulative effects of rolling friction and the significance of roll flattening, went back to Karman's work. Because of the apparent complexity of Karman's equations, Trinks had more than 10,000 individual point-by-point integration calculations carried out — and presented his results in the form of families of curves. In order to quantitatively evaluate the effect of flattening of the work rolls under high rolling pressures, Hitchcock[5], working with Trinks, worked out what is still the most satisfactory formula for taking these effects into account. Based on an elliptical distribution of contact pressures, and using Hertz's approach, Hitchcock's formula, cited in the earlier paper, was adopted as adequate recognition of this phenomenon. In a recent exhaustive study of rolling, with a view to being more exact, despite complications, Orowan[6] challenged Hitchcock's simplification, but his followers in Britain have more recently vindicated[7] Hitchcock's approximation. Trinks' paper presented all results in curve form — but offered no calculation procedure by which a rolling schedule could be set up for a given mill.

In 1939, Nadai[8] reviewed von Karman's work, and succeeded in analytically solving the fundamental differential equations, introduced for the first time the notion of constrained yield stress (=1.155 tension or compression yield stress), and further investigated the various possible types of roll bite friction. It was at this point that we initiated our studies and laid the basis[1] for the simplified but adequately accurate theory and calculation procedure that will be discussed in detail in this paper. Shortly thereafter, Keller[9] prepared a calculation procedure based on Trinks' earlier work, which followed similar lines of reasoning that we had developed, but which still was based on Trinks' families of curves, and still did not include the constrained yield stress notion. During the last ten years, considerable interest in metal rolling theory and

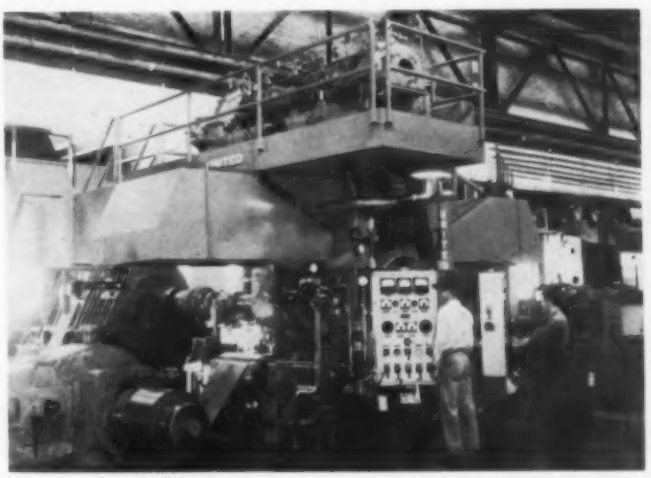


Figure 1 — High speed rolling of thin strip at Allegheny-Ludlum Steel Corp.

*Numbers refer to Bibliography at end of paper.

experimentation has been fostered in England by British Iron and Steel Research Association, (B.I.S.R.A.,) and the works of Orowan[6], Ford[10], and others, including the serialized reviews and book by Underwood[11] have currently turned renewed attention to these matters.

We wish to state at the outset what factors are considered important and what are unimportant or insignificant in their effects on the pressure and power required to cold roll strip, particularly in the lighter gages: (1) First of all, the mechanical properties of the strip, with due regard to its work hardening properties, must be recognized. (2) Due to the essentially extensional nature of plastic flow in cold rolling, the constrained yield stress rather than the conventional tension as compression yield stress must be considered. (3) The importance of frictional effects between work rolls and strip is of dominating importance, and these effects are calculated in a way to greatly simplify the designer's work, yet not jeopardize the accuracy of the procedure. (4) Of comparable significance in producing increased rolling pressures, (to the previous item) in the rolling of thin hard strip particularly, is the phenomenon of roll flattening — and this effect must be adequately dealt with. (5) Of mitigating influence are the effects of front and back tension in rolling, and these are properly recognized. (6) Bound up with these prior items, but of singular interest in itself, is the role of work roll diameter relative to strip thickness, as well as to back-up roll diameter. (7) Based on a proper evaluation of items (1) to (7), rolling pressures are obtained — which are translated into torque and power, through the correct value of torque-arm relative to arc of contact. (8) While speed effects in cold rolling are known to exist, these effects are somewhat indirect and enter our considerations only through their influence on bite friction. (9) Spread in rolling is considered of negligible consequence. (10) Extrusion effect (running ahead of the metal leaving the rolls) and position of no-slip point are considered of only secondary importance. (11) Such effects as elastic compression recovery, strip temperature, variation in rolling conditions in the arc of contact (except pressure) are considered of negligible direct effect. Based on the above recognition and recapitulation of pertinent effects, we now proceed to a detailed consideration of the inter-relation of the several factors.

Perhaps a word should be interpolated as to the inadequacy of the so-called energy method of roll pressure and pass schedule determination in the cold rolling of thin strip. Since considerable test information is available, based on power readings taken during rolling, giving energy to roll in hp-hr per ton as a function of reduction, the point is raised as to why may not the pressures be obtained by dividing the torque (readily calculated from the power readings) by the proper torque arm. This question is proper, and the procedure correct, but the difficulty lies in determining the correct value of the torque arm. Whereas for thick strip, when cold rolling the softer metals (and similarly true in hot rolling), the torque arm may be taken as essentially one-half the geometrically determined contact arc, this procedure is greatly in error when cold rolling the thinner, harder metals, being sometimes several hundred per cent in error. See Figure 6 of first paper[1], "Rolling Pressures in Strip Mills," by M. D. Stone and J. I. Greenberger, 1943 Proceedings of the AISE, p 109. In fact, in pursuing the proper procedure to determine this torque-arm, are we led into the method that will now be further developed.

We start first with the physical properties of the material to be rolled. Consider the strip coming to the mill at a thickness, t_1, and width w, (to be rolled to thickness, t_2) and having a compressive yield stress, $p_{y.s.}$, our first approximation to the rolling force, P, would be $P = p_{y.s.} w \sqrt{R(t_1 - t_2)}$ where R = radius of reducing rolls, the expression under the radical being the geometrical arc of contact, *l*. However, we realize immediately that the yield strength increases due to the cold working involved in the reduction, which effect is very considerable, particularly if starting with annealed stock. Therefore, we must have information as to the magnitude of these work hardening effects. Although possibly the preferable form in which to have this information would be from a series of simple compression tests on the material cold rolled to various thicknesses, or to various percentages of cold reduction

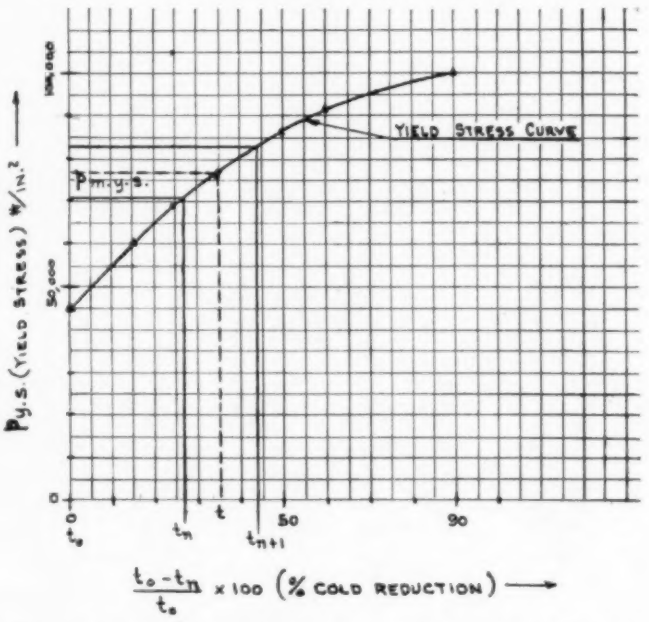


Figure 2 — Typical yield stress curve is shown for tin plate.

— simple tension tests will do substantially as well, since for ductile materials, the yield stress in compression and tension are essentially equal — and tension tests are more easily and conventionally made. In fact, a single tension test carried out to the ultimate, where true stress is plotted against reduction, would do almost equally as well. These points made in our original paper[1] have been more recently rigorously examined and reaffirmed. See "Einfluss Des Haspel—Und Bremszuges Auf Den Kaltwalzvorgang," by Lueg and Schultze, Stahl und Eisen, December 26, 1940. This latter work also confirmed the necessity of recognizing the constrained yield stress over ordinary yield stress, as originally pointed out by Nadai, and adopted by us.

Thus, we see that we must have a curve, as shown in Figure 2, of the work hardening properties of the metal to be rolled.

In order to simply, yet adequately — as we shall show — evaluate the importance of friction in the roll

bite, let us refer to Figure 3. Inextricably connected with this effect is that of roll flattening, and also the influences of front and back strip tension. In Figure 3b, we show the thin strip in contact with the flattened roll surface to be essentially a flat strip, rather than a flat wedge or a concave wedge section. This simplified

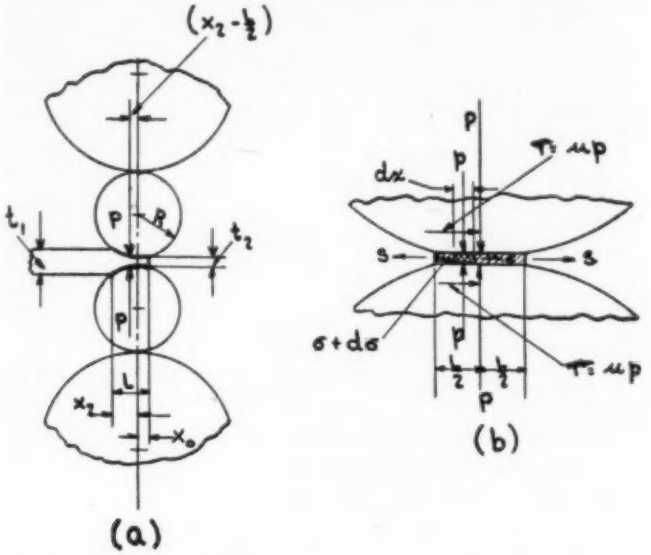


Figure 3 — Roll bite conditions are given by sketches.

assumption, which is used solely for the determination of total rolling pressure (and not pressure distribution, extrusion effects, position of no-slip point, etc.) is of great help in this approach to the problem, as we shall point out. This diagram permits us to write:

$$\frac{dp}{dx} = -\frac{2\tau}{t} \qquad (1)$$

where p = roll pressure (psi)
x = distance from center of pressure to point under consideration (in.)
τ = shear stress (psi)
t = strip thickness (in.)

For the usual assumption of Coulomb friction, $\tau = \mu p$, where μ = coefficient of friction, whence (1) becomes:

$$\frac{dp}{dx} = -\frac{2\mu p}{t} \qquad (2)$$

or by transposition:

$$\frac{dp}{p} = -\frac{2\mu}{t}\,dx, \text{ which integrated}$$

from $x = 0$ to $x = +\frac{L}{2}$, with external tensions, s, gives us

$$p = (s_o - s)\, e^{\frac{2\mu}{t}\left(\frac{L}{2} - x\right)} \qquad (3)$$

where it is assumed, with Nadai, that at each point, x, flow is governed by the condition, where σ = tension within bite (see Figure 3b);

$$p + \sigma = s_o \qquad (4)$$

s_o being the constrained yield stress, equal to $\frac{2}{\sqrt{3}} = 1.155$ times the simple compression or tension yield stress. In our case, the pressure distribution is symmetrical around the center of the contact length, L, so that we can write, for the total rolling pressure:

$$P = w \int_{-\frac{L}{2}}^{+\frac{L}{2}} p\,dx = \frac{w\,(s_o - s)\,t}{\mu}\left(e^{\frac{\mu L}{t}} - 1\right) \qquad (5)$$

from which, we obtain the mean roll pressure, $\bar{p}$, as

$$\bar{p} = \frac{P}{wL} = (s_o - s)\left(\frac{e^{\frac{\mu L}{t}} - 1}{\frac{\mu L}{t}}\right) \qquad (6)$$

This is an important formula, as originally pointed out — and in its development, many assumptions are involved, as well as in its use, that we shall discuss further. Primarily it says that the average pressure in the bite is equal to the constrained yield stress, s_o minus the external tension stress, s, times a factor (which we shall call Pressure Multiplication Factor or PMF) which is simply a function of the term $\frac{\mu L}{t}$. A plot of PMF in the first paper, repeated in Figure 4, shows how the pressure may reach 5 to 10 times the simple compression yield stress, and points up the importance of the proper determination of the values for μ, L, and t. The simplicity and value of such an analytical expression requires a defense of its development, else the purists will not be willing to accept it. This factor, PMF, is in reality the equivalent of Trinks' large number of graphical integrations, as assembled in his chart, Figure 1 of Reference 4. Let us compare the two for relative accuracy. Take first a case of a large work roll

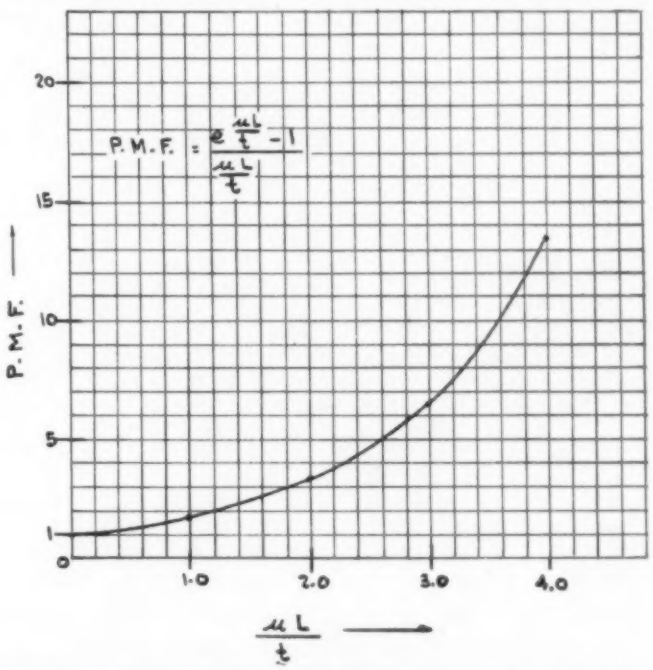


Figure 4 — Pressure multiplication factor (PMF) is shown as a function of parameter $\frac{\mu L}{t}$.

and thin material taking a 20 per cent reduction, say $t_1 = 0.020$ in, $t_2 = 0.016$ in. For a 20-in. diam roll, considerable roll flattening occurs, so that $L = 0.56$ in. Let us further take an average value for μ of 0.10. Thus

$$\frac{\mu L}{t} = \frac{0.10 \times 0.56}{0.018} = 3.1,$$ and our curve for PMF gives 7.0. Trinks' notation gives:

$$\frac{m}{H} = \frac{t_1 - t_2}{t_1} = \frac{0.020 - 0.016}{0.020} = 0.2$$

$$\text{and } \frac{L}{m} \tan f = \frac{\mu L}{t_1 - t_2} = \frac{0.10 \times 0.56}{0.004} = 14.$$

The corresponding chart value for $\frac{\text{average roll pressure}}{\text{natural flow resistance}} = 7.4$, which is 5.7 per cent higher than our value. As another check, take the case of a smaller work roll, taking a larger reduction on thicker material, viz. $t_1 = 0.050$ in., $t_2 = 0.035$ in., $D = 15$ in. diam, and $\mu = 0.10$, as before. In this case, there is much less roll flattening, and L is taken as 0.60 in. Thus $\frac{\mu L}{t} = \frac{0.1 \times 0.60}{0.0425} = 1.41$, resulting in a relatively low value of PMF = 2.2. Trinks' values are $\frac{m}{H} = \frac{t_1 - t_2}{t_1} = \frac{0.050 - 0.035}{0.050} = 0.3$ and $\frac{L}{m} \tan f = \frac{\mu L}{t_1 - t_2} = \frac{0.10 \times 0.60}{0.015} = 4$, yielding

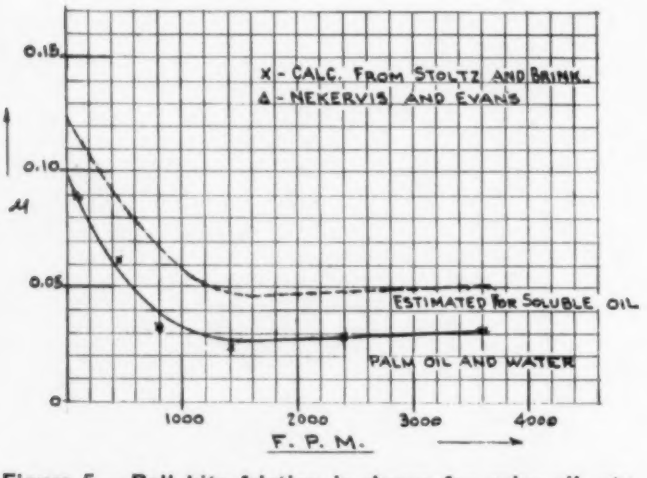


Figure 5 — Roll bite friction is shown for palm oil, etc.

from the chart a ratio value of 2.1, which is 4.6 per cent lower than ours. Thus the relative accuracy of the two methods can be said to be established, with great simplicity for the formula of equation (6).

Of first importance is the proper value of friction between the strip and the rolls. Many tests have been made to ascertain values of μ for the cold rolling of metals, under high specific pressures, and for various lubricants. Lueg and Pomp [12] deduced values from the forward slip or extrusion effect when rolling steel, and found that values ranged from 0.07 to 0.12 for a wide range of lubricants, and smooth rolls, although stating that if the rolls were rough, values up to 0.15 could be obtained. Speeds were about 5 fpm. Trinks[13] has stated that he has determined values as low as 0.04 for high speed rolling. Orowan and Los[14] in an extensive series of tests on a special test rig (not simulating rolling conditions) increased the range to 0.20. By far the best series of tests on rolling lubricants has been carried out by Nekervis and Evans[15], although limited as to speed range. Values were determined under actual rolling conditions, where from measurements of total pressure, P, and final thickness, t_2, values of μ were obtained directly — utilizing the theory of rolling discussed here. How this may be done will be elucidated later, but suffice it to say at this point that values ranged from 0.08 to 0.12, and it is the writer's feeling that these are our truest values for speeds around 120 fpm, as tested. Although the range from poor to the best lubricants does not seem great, their effect through the agency of PMF is truly considerable. The variation of μ with speed is of considerable interest to us, as will be gone into later. Complete test data[16] recently made available on a 5-stand tandem mill running up to 5000 fpm, has enabled us to calculate back what these roll bite frictions are. In Figure 5, we have plotted these values, showing how for palm oil as a lubricant and water as a coolant, the value of μ drops from an initial value of 0.09 for low speeds to 0.03 for speeds in excess of 1000 fpm, and remains essentially constant up to over 4000 fpm. For soluble oils, we would expect a similar curve, starting at say 0.11 and dropping to 0.05, as observed by Trinks. It is interesting and pertinent to recollect, in this connection, that early tests by G. Westinghouse and D. Galton[17] on dry friction showed the μ value to drop to almost one third in going from 1000 to 5000 fpm.

The next value of importance to discuss, relative to equation (6), is the value of L, the contact length between strip and work roll. Because of the way its value enters into the equation, we can realize its importance also. Since it is known that under rolling pressure, the work rolls deform and flatten, it is readily appreciated that L must be considerably larger than the "rigid roll" contact length, $l = \sqrt{R(t_1 - t_2)}$, where $R = \frac{D}{2}$ = radius of work roll. Actually Hitchcock's formula[5] has adequately evaluated this effect, as explained earlier, our preferred form, referring to Figure 3, being:

$$L = \sqrt{l^2 + x_0^2} + x_0 = x_2 + x_0, \text{ or}$$

$$L = \sqrt{R(t_1 - t_2) + \left[\frac{8R(1 - \nu^2)}{\pi E} p\right]^2} + \frac{8R(1 - \nu^2)}{\pi E} p \quad (7)$$

where, in addition to previous notations,

ν = Poisson's ratio (= 0.3, for steel)

E = Modulus of elasticity (= 30,000,000 psi for steel)

The third factor in our important parameter, $\frac{\mu L}{t}$, is t. Here since the strip has an entering thickness, t_1, and a leaving thickness, t_2, we interpret t to be the average strip thickness through the bite, i.e. t ($= t_{ave.}$)

$= \frac{t_1 + t_2}{2}$. The correctness of this assumption is attested by our earlier comparison with Trinks' step-by-step integration method.

The next major effect on roll pressure that we must properly evaluate is that of front and back tension. In equation (4), we have expressed the fundamental relation coming out of basic considerations of plastic flow. The question is raised as to whether this expression correctly covers the facts in actual rolling. Early observations made along these lines by Hayes and Burns[18], were later corroborated by the writer in a more extensive series of tests on the same apparatus; but we shall cite here the tests of Lueg and Schultze[19], which we had referred to in our first paper. We first

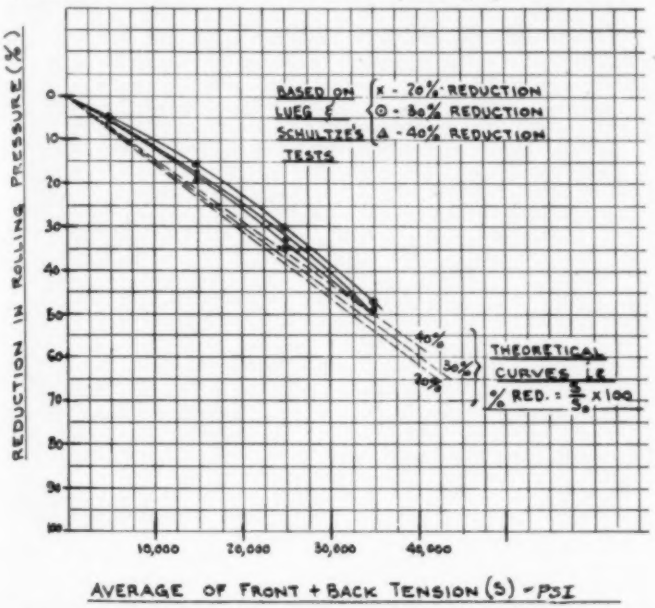


Figure 6 — Influence of tension on rolling pressure is shown on curves.

should note that these tests showed reductions in rolling pressure of up to 35 per cent by heavy back tension, and up to 20 per cent by heavy front tension. It is definitely established that back tension is the more effective in this regard, probably acting, as well, to decrease the contact length, and hence the PMF value. However, in our analysis, we wish to retain simplicity with accuracy — and in this instance, we gain an improvement in accuracy, as well. By using average tension, i.e., the median value of front and back tension when acting together, we can recast Figure 9 of our first paper to give Figure 6. Here are replotted three curves corresponding to 20, 30, and 40 per cent reduction respectively. The test curves fall quite closely together, exhibiting no clear differentiation between the various values. The theoretical curves are based on the equation below, with proper regard for the correct value of s_o. The material that was being rolled had a starting tension yield stress of 43,000 psi, increasing to 85,000 psi after 70 per cent reduction. After 20 per cent, the value was 65,000 psi, so that the average value of s_o would be $1.155 \times \left(\frac{43{,}000 + 65{,}000}{2}\right) = 63{,}000$ psi. For 30 per cent, $s_o = 70{,}000$ psi, and for 40 per cent, $s_o = 72{,}000$ psi. Now, from above, we have $\bar{p}_2 = (s_o\text{-}s)$ PMF and $\bar{p}_1 = (s_1)$ PMF, whence $\frac{\bar{p}_2 - \bar{p}_1}{\bar{p}_1} \times 100 = \frac{s_o}{s} \times 100 =$ per cent reduction in roll pressure. Thus for a value of average tension of 35,000 psi when reducing 40 per cent, the anticipated reduction in rolling pressure would be $\frac{35{,}000}{72{,}000} \times 100 = 49$ per cent, as plotted, which also happens to be the test value. Not such good coincidence is found for the other test points, but general agreement is good, and adequately validates our method of procedure. It is to be noted that here again, we deal with the average value of s_o in the bite, just as we have earlier, with the average values of thickness, t, and tension, s.

Efforts till now have concentrated on the proper prediction of roll pressures. Now we must proceed to the calculation of torque, so that power may be constantly kept in line with that available on a given mill — when rolling schedules are being forecasted. A direct consequence of our simplifying procedure, with reference to Figure 3 and leading up to equation (5) would be that the resultant pressure, P, acts in the centre of the contact length L — and that the moment arm of the rolling pressure, P, be given by

$$\text{Moment arm} = \left(x_2 - \frac{1}{2}L\right) \qquad (8)$$

See Figure 3a. That we are justified in making this assumption comes as a result of many observations over the years. Particularly for cold rolling, do the observed values vary around ½. Our choice to adhere to 0.50 has more recently been greatly fortified by careful experimental work by Ford [10] in 1948, although his work would indicate that 0.45 might be somewhat better.

Now, as we listed at the outset, several simplifying assumptions have further been made. We have assumed, for instance, that roll pressures and torques are independent of the speed of rolling. We wish to clarify this point further. By and large, over a long period of years, much power and energy data has been taken — and the total hp-hr per ton to effect a certain reduction has been essentially independent of the speed of rolling. The best example would be that of tin plate — where speeds have increased from 350 fpm in 1928 to more than 5000 fpm in 1950, without any essentially different power consumptions involved. This leads one to infer that speed effects, if any, are of a secondary nature. Tests on deformation forces over a wide range of speeds made by Nadai and Manjoine [20], quoted in our first paper, show that at temperatures in the vicinity of room temperature, that not only may the required forces to deform not increase with speed, but may actually decrease at times. However, it is equally as well established for a long time now[16] that as the speed of rolling is increased, strip gage decreases quite considerably. For example, on the last pass, when rolling tin plate to a thickness of 0.010 in. at a full speed of say 4000 fpm, the gage will increase to 0.013 in., as the speed is decreased as the end of the strip is reached, the major gage variation taking place below 1000 fpm. There are undoubtedly many factors involved in this phenomenon,

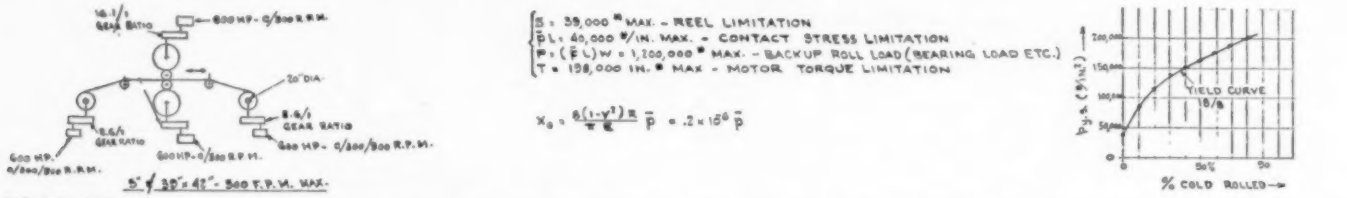
such as change in temperature of the strip, the response of the particular analysis of metal being rolled to rate of deformation, change of relative roll position (due to oil film thickness changes), and most importantly, the friction coefficient between the rolls and the strip.

Ford's [21] work on this subject has been particularly pertinent, and the writer is willing to accept his experimental results showing very considerable decreases in pressure with speed when rolling thin hard metals where considerable roll flattening is involved. Our explanation of this effect is that the coefficient of friction, μ, in combination with the flattened length, L, where the thickness, t, is small, are all reflected in the $\frac{\mu L}{t}$ influence, cited earlier, and cover the phenomenon adequately. Actual speed, as such, is not the explanation, as Ford points out, since for the same speed range no appreciable decrease in pressure is observed for thicker, softer strip, i.e., in the early passes. Let us say, for instance, that in going from 500 fpm to 1000 fpm, the value of μ decreases from 0.08 to 0.05. Where the strip is thick, the $\frac{\mu L}{t}$ value would correspondingly decrease from say, 0.50 to 0.31, meaning a decrease in PMF from 1.29 to 1.17, or a decrease in pressure of only 10 per cent. However, where the strip is thin, the decrease in the $\frac{\mu L}{t}$ value from say 2.00 to 1.25, would cause a decrease in the PMF value of from 3.20 to 1.99, or a decrease in pressure of 38 per cent.

Our last consideration of assumptions is to observe that in strip rolling, particularly for the cold rolling of thin strip, the change in strip width is insignificant, leading to our justification that rolling pressures and powers may be properly taken as directly proportional to strip width. Connected with this consideration is that of constrained deformation in the direction of rolling alone, which raises the resistance to reduction by the ratio $\frac{2}{\sqrt{3}} = 1.155$, as pointed out previously by Nadai[8].

We are now ready to demonstrate our calculation procedure, and in this connection, the method may be followed by referring to pass 1 in the calculated table given in Figure 7. Starting with a given or assumed mill design, i.e., work roll diam and length, back-up roll dimensions, known bearing ratings, and established motor powers and speeds, we next require a curve of the yield stress of the material being rolled, such as is illustrated in Figure 2.

1. From the starting thickness t_1, assume the strip can be reduced to a thickness, t_2.


16.1/1 GEAR RATIO
600 HP.- 0/300 R.P.M.
20" DIA.
8.6/1 GEAR RATIO
600 HP. 0/300/900 R.P.M.
600 HP.- 0/300 R.P.M.
600 HP.- 0/300/900 R.P.M.
5" x 39" x 42" - 900 F.P.M. MAX.
S = 39,000 # MAX. - REEL LIMITATION
p̄L = 40,000 #/IN. MAX. - CONTACT STRESS LIMITATION
P = (p̄ L) w = 1,200,000 # MAX. - BACKUP ROLL LOAD (BEARING LOAD ETC.)
T = 138,000 IN.-# MAX - MOTOR TORQUE LIMITATION
$x_o = \frac{8(1-\nu^2)\pi}{E}\bar{p} = .2 \times 10^{-6}\bar{p}$
YIELD CURVE
18/8
% COLD ROLLED

30" WIDE STRIP

PASS NO.	t_1, t_2 IN.	$t_1 - t_2$ IN.	RED. %	TOTAL RED. %	$p_{y.s.}$ #/IN.²	$p_{m.y.s.}$ #/IN.²	s_o	s #/IN.²	$\bar{p}_1 = s_o - s$ #/IN.²	$B = \frac{\bar{p}_1}{w t_1}$	$R(t_1-t_2) = l^2$	X_o IN.	X_o^2 IN.	$x_2 = \sqrt{l^2 + x_o^2}$	$L_1 = x_2 + x_o$	L_2 EST.	μ	t IN.	$\frac{\mu L}{t}$	PMF	$\frac{\bar{p}_2}{\bar{p}_2 PMF}$	x_o	x_o^2	x_2	L IN.	$\bar{p}L$ #/IN.	$P = \bar{p}LW$	ARM: $Q = P\left(\frac{t_1 - t_2}{2}\right)$ IN.-#	$T = 2Pa$ IN.-#
0	.125	-	-	-	35,000	—	—	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1	.101	.024	19.2	19.2	115,000	84,000	97,000	13,000	90,500	38,000	.0800	.0181	.0003	.246	.264	.266	0.10	.113	.235	1.126	101,700	.0203	.0004	.246	266	27,500	800,000	.113	181,000
2	.085	.016	15.8	32.0	140,000	127,500	147,000	19,500	152,000	38,000	.0400	.0268	.0006	.202	.228	.240	0.10	.083	.258	1.138	150,000	.0300	.0009	.202	232	35,000	1,050,000	.086	184,000
3	.072	.013	15.3	42.2	155,000	147,500	171,000	18,300	152,000	38,000	.0325	.0304	.0009	.188	.215	.220	0.10	.079	.280	1.153	175,400	.0351	.0012	.184	220	38,500	1,150,000	.074	171,000
4	.061	.011	15.3	51.2	166,000	160,500	186,000	21,600	164,000	38,000	.0275	.0326	.0011	.168	.202	.208	0.10	.067	.314	1.175	182,500	.0385	.0015	.170	.206	40,200	1,208,000	.066	159,000
5	.052	.009	14.7	58.3	175,000	168,500	196,000	25,400	170,000	39,000	.0225	.0341	.0012	.154	.188	.196	0.10	.057	.347	1.195	203,500	.0407	.0017	.155	.196	39,900	1,197,000	.057	137,000
6	.045	.007	15.5	64.1	182,000	178,500	206,000	29,400	177,000	39,000	.0175	.0353	.0012	.137	.172	.181	0.10	.049	.374	1.215	214,000	.0428	.0018	.139	.182	38,000	1,176,000	.048	115,000
7	.039	.006	13.3	68.7	188,000	184,000	217,000	33,900	183,000	39,000	.0150	.0366	.0013	.128	.165	.176	0.10	.042	.420	1.240	227,000	.0494	.0021	.131	.176	40,000	1,240,000	.043	103,000
8	.034	.005	12.7	72.5	192,500	190,250	220,000	38,800	181,000	38,000	.0125	.0362	.0013	.118	.154	.166	0.10	.037	.455	1.265	229,000	.0458	.0021	.121	.166	38,600	1,163,000	.037	86,000
9	.029	.005	14.7	76.3	187,000	194,750	225,000	45,500	179,000	38,000	.0125	.0360	.0013	.118	.153	.167	0.10	.032	.530	1.320	236,500	.0473	.0022	.122	.168	38,800	1,195,000	.037	88,000
10	.025	.004	13.8	80.0	201,000	198,000	238,000	50,000	188,000	38,000	.0100	.0384	.0015	.105	.141	.158	0.10	.027	.585	1.357	240,000	.0480	.0025	.111	.159	40,700	1,220,000	.031	76,000
11	.022	.003	12.0	82.5	204,000	202,500	234,000	50,000	184,000	38,000	.0075	.0368	.0014	.094	.131	.155	0.10	.0235	.660	1.415	260,000	.0520	.0027	.101	.153	38,900	1,190,000	.024	57,000
12	.020	.002	9.0	84.0	206,000	205,000	236,500	50,000	186,500	38,000	.0050	.0373	.0014	.080	.117	.145	0.10	.021	.680	1.434	268,000	.0536	.0029	.089	.142	38,200	1,150,000	.018	42,000
13	.018	.002	10.0	85.8	208,000	207,000	239,000	50,000	189,000	37,000	.0050	.0378	.0014	.080	.118	.145	0.10	.018	.763	1.505	284,500	.0569	.0032	.081	.147	42,000	1,260,000	.017	43,000
14	.0165	.0015	8.3	87.0	209,000	208,500	241,000	52,000	191,000	38,000	.0038	.0382	.0015	.072	.111	.140	0.10	.0175	.811	1.546	298,000	.0550	.0035	.085	.142	42,000	1,260,000	.014	35,000
15	.0155	.0010	6.1	87.5	210,000	210,000	242,000	50,000	192,000	24,000	.0025	.0384	.0015	.065	.102	.135	0.10	.016	.844	1.569	301,000	.0602	.0036	.078	.138	41,700	1,250,000	.009	23,000
16	.0150	.0005	3.2	88.2	211,000	211,000	244,000	50,000	194,000	23,000	.0013	.0388	.0015	.055	.091	.130	0.10	.0155	.853	1.577	306,000	.0612	.0037	.071	.132	40,500	1,210,000	.008	12,000

Figure 7 — Table shows calculation procedure.

2. From yield stress curve, determine the mean yield stress $p_{m.y.s.}$ corresponding to $t = \frac{t_1 + t_2}{2}$, as indicated.
3. Multiply by 1.155, because of constrained yield stress phenomenon to obtain corresponding value of s_o i.e., $s_o = 1.155\ p_{m.y.s.}$
4. Subtract average of front and back tension stress, s, based on assumed value of both i.e., form $\bar{p}_1 = 1.155\ p_{m.y.s.} - s$, thus reducing the required pressure and particularly the roll flattening effect.
5. List value of $R(t_1-t_2) = l^2$, where l = contact length of unflattened roll.
6. Calculate and list value of $x_o = \frac{8R(1-\nu^2)}{\pi E}\ p_1$
7. Form and list value of $x_2 = \sqrt{l^2 + x_o^2}$
8. Form and list value of $L_1 = x_2 + x_o$, which is the

first approximation to value of flattened roll arc of contact.

9. Estimate L_2, somewhat greater than L_1, as true contact length, as it is known that frictional effects will always increase this value.
10. Form $\frac{\mu L_2}{t}$ where $t = \frac{t_1 + t_2}{2}$, and μ is taken as 0.10, unless known conditions indicate differently.
11. List PMF — from curve or table, as a function of $\frac{\mu L}{t}$.
12. The adjusted pressure, p, is formed, and is equal to $\bar{p}_1 \times$ PMF.
13. Based on $\bar{p}$, repeat calculations (6), (7), and (8) leading to a new value of L. If this value comes out equal to L_2, then we have a correct solution. If not, adjust L_2 upward or downward, and repeat till equality is obtained.
14. List final value of $\bar{p}$ and also total pressure $P = wL\bar{p}$. This latter value must be within the limits set by capacity of back-up bearings (if a back-up mill) and/or contact stress between work and backing rolls.
15. List torque arm, $a = \left(x_2 - \frac{L}{2}\right)$
16. List rolling torque, $= 2P\left(x_2 - \frac{L}{2}\right)$ to which should be added roll friction torque (due to friction in bearings). This value must be within the permissible torque rating of the mill motor referred to the work rolls. If either load, item (13), or torque, item (15), are in excess of the permissible values, then the calculations must be repeated from the beginning.

The above procedure is carried through for the second pass, the third pass, and so on, till the final desired gage is reached, if possible. What is meant by this last statement is that it very often happens that it is impossible to reach certain thin gages when rolling hard metals. What happens calculation-wise, is that no value of L can be found to satisfy the conditions of items (9) and (13), as inter-related by the intermediate steps. What this means practically is that the required rolling pressure, either by virtue of the high value of $p_{m.y.s.}$ caused by work hardening or by the high value of PMF as influenced by $\frac{\mu L}{t}$, causes the rolls to deform, instead of the strip to be reduced. This means that to continue reducing, the strip must be annealed, and thus further reduction becomes possible.

A study of these critical conditions must now be gone into. What we are confronted with is meeting the simultaneous conditions dictated by equations (6) and (7); except that we wish to rewrite the latter, by multiplying through by $\frac{\mu}{t}$, and simplify by letting $a = \frac{8R(1-\nu^2)}{\pi E}$. Thus, we have:

$$\bar{p} = (s_1 - s)\frac{e^{\frac{\mu L}{t}} - 1}{\frac{\mu L}{t}}$$

$$\left(\frac{\mu L}{t}\right) = \sqrt{\left(\frac{\mu l}{t}\right)^2 + \left(\frac{\mu a}{t}\right)^2 \bar{p}^2} + \left(\frac{\mu a}{t}\right)\bar{p} \qquad (9)$$

If we now plot these equations with $\bar{p}$ as a function of $\left(\frac{\mu L}{t}\right)$, we get the characteristic curves shown in Figure 8. The plot is a graphical solution of the two simultaneous equations (9a) and (9b), and the "operating point" is that point arrived at by the trial-and-error process described in the calculating procedure. From this curve, we see that for a value of $(s_o - s) = 50{,}000$ psi, the $\left(\frac{\mu L}{t}\right)$ value is 0.63, corresponding to a PMF value of 1.4, which when multiplied by 50,000 psi, yields a $\bar{p}$ value of 70,000 psi. The intercept on the abscissa-axis, $\left(\frac{\mu l}{t}\right)$, is a measure of the reduction

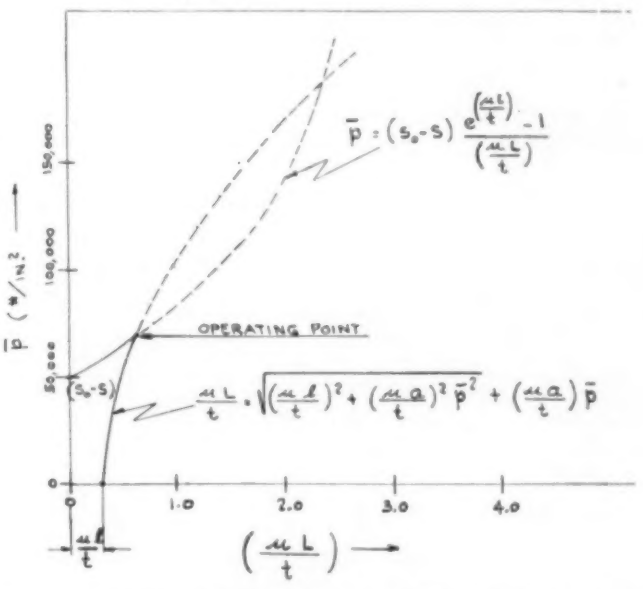


Figure 8 — General conditions for rolling of thin strip.

being taken. It is seen that considerably more reduction could be taken — and still have the two curves intersect, i.e., a possible rolling condition would still exist — provided the bearing and motor capacities would permit it. This limiting condition is shown in Figure 9, where the curve of (9b) is simply moved to the right parallel to itself, until only a point of tangency remains. We now see, compared to Figure 8, that the operating point is now characterized by a $\left(\frac{\mu L}{t}\right)$ value of 1.5, corresponding to a mean rolling pressure of 115,000 psi,

and that the reduction has increased several fold, since $\left(\frac{\mu l}{t}\right)$ is now 0.80 compared with 0.32, for Figure 8.

In passing, mention might be made of the possibility of a second set of compatible rolling conditions, corresponding to the second intersection point in Figure 8, but this is an imaginary condition wherein the roll is deformed more than the strip.

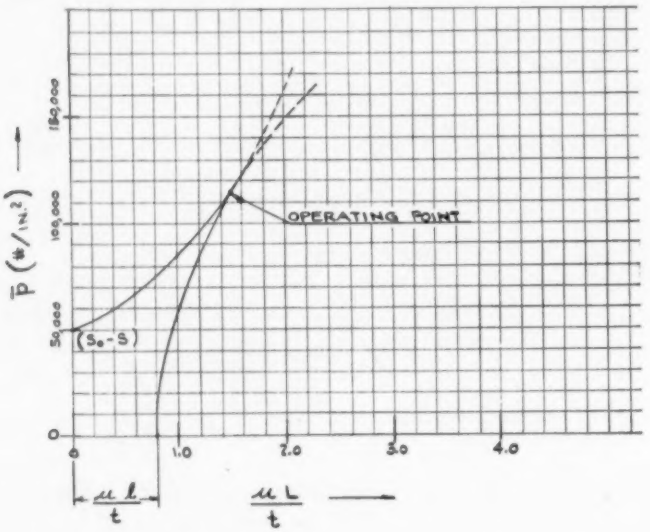


Figure 9 — Limiting rolling condition as set by maximum possible reduction.

Another interesting and important condition is shown in Figure 10, where the limit of rollability is that no reduction on the strip can be taken, due to the flattening of the roll. This condition is defined by $\left(\frac{\mu l}{t}\right) = o$, in equation (9b), leading to:

$$\left(\frac{\mu L}{t}\right) = 2\left(\frac{\mu a}{t}\right)\bar{p} \qquad (10)$$

with the further stipulation that this curve (straight line) is tangent to the (9a) curve. This point is defined by the condition, referring to equation (9a) and calling $\lambda = \left(\frac{\mu L}{t}\right)$, that the slope,

$\frac{d\bar{p}}{d\lambda} = (s_o\text{-}s)\ \frac{\lambda e^{\lambda} - (e^{\lambda} - 1)}{\lambda^2}$ equals $\frac{\bar{p}}{\lambda}$ at the point of tangency. Thus

$$(s_o\text{-}s)\ \frac{\lambda e^{\lambda} - (e^{\lambda} - 1)}{\lambda^2} = (s_o\text{-}s)\ \frac{e^{\lambda} - 1}{\lambda} \div \lambda, \text{ or}$$

$$\lambda e^{\lambda} - 2\,(e^{\lambda} - 1) = o \qquad (11)$$

This equation defines this point. It is to be noticed that this value of $\lambda_{critical} = \left(\frac{\mu L}{t}\right)_{critical}$ is independent of $(s_o\text{-}s)$, and holds for all curves, as indicated in Figure 10, by the curves above and below the one under particular scrutiny. Solving (11), we arrive at the result, $\left(\frac{\mu L}{t}\right)_{crit.} = 1.594$. Now the slope of the critical tangent is $(s_o\text{-}s)\ \frac{e^{1.594} - 1}{(1.594)^2} = 1.54\ (s_o\text{-}s)$; and the slope of the limiting flattening line, from (10), is $\frac{t}{2\mu a}$. These are identical for the critical condition, so that $1.54\ (s_o\text{-}s) = \frac{t}{2\mu a}$, or

$$t = 3.08\ \mu a\ (s_o\text{-}s) = \frac{(3.08)\ (4D)\ (1 - \nu^2)\ \mu\ (s_o\text{-}s)}{\pi E}.$$

This is the minimum value of strip thickness, t_{min}, that can be rolled on the mill having a work roll diam, D, made of a material having a modulus of elasticity, E, the bite friction being, μ, the metal constrained yield stress being, s_o, and the average strip tension being s i.e.:

$$t_{min} = 3.58\frac{D\ \mu\ (s_o\text{-}s)}{E} \qquad (12)$$

which is an extremely important relationship.

The above equation answers the question "How thin can strip be rolled?" for all combinations of conditions—quantitatively as well as characteristically. Let us consider, for example, three widely differing metals: aluminum foil, tin plate, and stainless steel. Since 2S aluminum foil, even when cold rolled 90 per cent or more, has a yield stress of 22,000 psi, $s_o = 1.155 \times 22{,}000 = 25{,}000$ psi. Tensions used are of the order of 10 lb per in., corresponding to 10,000 psi — so that $(s_o\text{-}s) = 15{,}000$ psi. For a 9-in. and 33-in. × 30-in. foil mill, having a top speed of 800 fpm, and using C - metal rolling oil, μ may be taken as 0.06, so that:

$$t_{min} = \frac{3.58 \times 9 \times 0.06 \times 15{,}000}{30 \times 10^6} = 0.0010 \text{ in.}$$

That this checks actual practice is observed from the fact that to produce 0.00035-in. foil, the strip is conventionally doubled at 0.0007 in., i.e., a double strip, having a composite thickness of 0.0014 in., is reduced 50 per cent to 0.0007 in., and then separated, yielding the desired final gage. For this condition, $t = \frac{0.0014 + 0.0007}{2} = 0.0010$ in. In the case of the high speed rolling of tin plate, now, on a 5000-fpm, 5-stand tandem mill, 21-in. and 53-in. × 41 in., using palm oil and water, μ may be taken as low as 0.03. For full hard material, $s_o = 1.155 \times 100{,}000 = 115{,}000$ psi, and conventional tensions are 40,000 psi. Thus

$$t_{min} = \frac{3.58 \times 21 \times 0.03 \times (115{,}000 - 40{,}000)}{30 \times 10^6} = 0.0055 \text{ in.}$$

which again closely checks known gage limits. For 18/8 stainless, being reduced to its minimum gage without annealing, on a 12-in. and 49-in. × 42-in. mill, operating at 500 fpm, utilizing soluble oil, a μ of no lower than 0.07 can be expected. For full hard material, a yield stress of 190,000 psi is involved, so that $s_o = 1.155 \times$

190,000=220,000 psi. Tensions again of the order of 40,000 psi, or higher, may be used, so that:

$$t_{min} = \frac{3.58 \times 12 \times 0.07 \times (220{,}000 - 40{,}000)}{30 \times 10^6} = 0.018 \text{ in.}$$

can be reached. Again this checks best current practice.

Reference must be made in this connection to an early study of this matter by Keller[22] who approached the problem correctly — but failed to arrive at a general solution, such as is given by equation (12). By means of a step-by-step solution, for a particular case, Keller arrived at a particular numerical answer, which we check quite exactly (except that Keller neglected to include the constrained yield stress factor). His example was for a mill having a work roll diam of D=18 in., a yield stress of 110,000 psi, an assumed coefficient of friction of $\mu = 0.04$, and two values of tension, namely 0 and 33,000 psi. Substituting these values in equation (12), the values of t_{min} are 0.0110 in. and 0.00081 in. respectively. However, if the factor 1.155 is neglected, the calculated values would be 0.0096 in. and 0.0067 in. respectively — which check Keller's values exactly.

Let us return now to the matter of the importance of bite friction, μ. From equation (12), we see that an easy manner suggests itself of determining the value of this important factor, by experiment. By setting up a mill, with work rolls of a given diam, D, and modulus E, and rolling strip of known yield stress properties, s_o (with or without tension, s) to the minimum gage possible, we would then be able to directly determine μ by means of (12) transposed to:

$$\mu = \frac{0.28\ E}{D\ (s_o - s)}\ t_{min} \qquad (13)$$

Nekervis and Evans, cited earlier[15], attacked the problem in a somewhat similar fashion — but at that time, our criterian for t_{min} had not been worked out, as given here.

Referring now to equation (7), we transpose and square both sides, to get:

$$\left[L - \frac{8\,R\,(1-\nu^2)}{\pi\,E}\,\bar{p}\right]^2 = R\,(t_1 - t_2) + \left[\frac{8\,R\,(1-\nu^2)}{\pi\,E}\,\bar{p}\right]^2$$

This simplifies to:

$$L^2 - \frac{16\,(\bar{p}\,L)\,R\,(1-\nu^2)}{\pi E} = R\,(t_1 - t_2)$$

Now since $\bar{p}L = \frac{P}{w}$ we substitute, and obtain finally:

$$L = \sqrt{R\,(t_1 - t_2) + \frac{16\,PR\,(1-\nu^2)}{\pi\,w\,E}} \qquad (14)$$

This is our preferred form, in which we see that the flattened length, L, can be determined directly from observed test data on total load, P, and reduction, $(t_1 - t_2)$. Now equation (6) can be rewritten in the form:

$$\frac{P}{w\,L(s_o - s)} = PMF = \frac{e^{\frac{\mu L}{t}} - 1}{\frac{\mu L}{t}} \qquad (15)$$

Thus we see that for any rolling schedule, where rolling pressures and strip tensions are measured, the value of μ can be accurately calculated from the data. From the load reading and reduction, and using the mill data, L can be calculated from (14). Knowing L and P, and based on knowledge of the material being rolled and the tensions used, PMF can be determined from (15). Then by looking on curve for $\frac{\mu L}{t}$ vs PMF (Figure 4), the corresponding value of $\frac{\mu L}{t}$ is found. Having determined L, and knowing t, the value of μ is thus determined. Nekervis and Evans using essentially this procedure, making some compromise approximations, thus evaluated all their rolling oils under actual rolling conditions, and accordingly have determined what should be considered the most satisfactory values of μ, however only at the low speed of their experimental mill.

Applying this procedure, and using actual test data on a high speed mill rolling tin plate, as published by Stoltz and Brinks[16], we have been able to establish, for the first time, how μ varies with speed over a wide range. Figure 11 lists the test data on a particular run, and gives as well the calculation steps leading up to the determination of μ, using material data as shown in Figure 2. These final values of μ are shown in Figure 5, supplemented by Nekervis' data and shows how μ drops to less than 0.03 at speeds above 1000 fpm, although starting as high as 0.10 at low speeds.

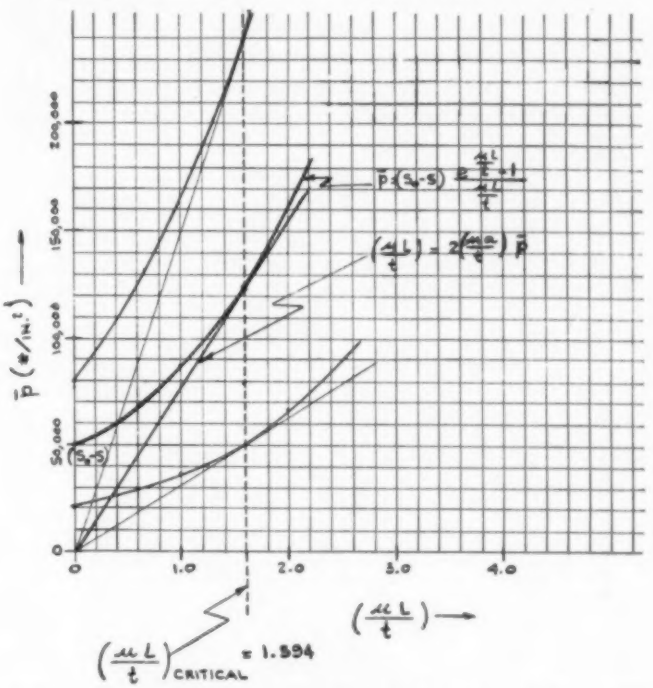


Figure 10 — Limit of rollability as set by no possible reduction.

Of closely allied interest is the apparent correlation of this curve and the variation of final gage with speed shown in Stoltz's paper. This shows how the gage actually increases slightly at speeds from 1000 to 5000 fpm, and rising sharply below this same 1000 fpm, as the mill slows down. This matter of gage increase as

the mill speed decreases has raised puzzling questions for sometime now — and was one of the major objectives of the Stoltz investigation. In these tandem mill runs, the rolling pressures decreased, probably because of increasing inter-stand tensions, during these slowdowns — concurrently with the gage increases. One of the main factors causing this increase was thought to be shift of roll position in the oil film bearings used on the mill. However, it must be pointed out that this phenomenon of gage increase with decreasing speed takes place on roller bearing mills — as observed by Ford[21], and others — where tensions were maintained constant (at zero value) and where the rolling pressures increased. These seemingly contradictory facts indicate that this gage increase phenomenon must have to do with conditions within the bite, and because of the striking parallel of μ-and gage-variations with speed, lead one to conjecture as to the interrelation of these actions. Can it be that the speed increase is such as to create a hydrodynamic condition between the work rolls and strip, in spite of the high specific pressures? The existence of such a fluid or semi-fluid film at the higher speeds, would at the same time explain the gage decrease and friction decrease with increase of speed, and vice versa. It is known that at high pressures, viscosities increase many fold, even more than a hundred times for specific pressures around 200,000 psi, and that some sort of film must exist, despite the high pressure, in order to adequately explain the drop in friction. This point will be scrutinized closely as opportunities present themselves in the future.

Now that we have discussed the various theoretical aspects of thin strip rolling, the questions remaining have to do with the most appropriate mills to accomplish such rolling. As a starting point, let us refer to equation (12). Here we see that in order to attain lighter gages, we should tend toward smaller work roll diam, D. We see further that in order to offset the effects of the harder alloys (high values of s_o) in attaining these lighter gages, we should use as high front and back tensions as are practicable (make $(s_o\text{-}s)$ as small as possible). We see further that whatever can be done to lower μ should be adopted. This we realize we can only influence, as far as mill design goes, by running at higher speeds. And lastly, we see that any increase in E would help, should this be attainable at reasonable costs. With these significant points established, let us discuss each one in greater detail.

The matter of work roll diam is of primary concern. The choice of the best value of D is very much a function of the material to be rolled. For aluminum foil, for instance, as we have seen earlier, a $\frac{D}{t_{min}}$ ratio of 9000/1 can be permitted, or even higher, as foil rolling speeds are increased. So that for a final gage of 0.001 in., a 9-in. work roll, or even higher, is indicated. For tin plate, a $\frac{D}{t_{min}}$ ratio of 4000/1 is permissible when using palm oil at high speeds, or somewhat less, at lower speeds, so that a minimum final gage of 0.007 in. would require a work roll no smaller than say 25 in. The question might well be raised here what is the upper limit? Of course, the larger the work roll, the longer it lasts between regrinds, and the less the production interferences. However, increased rolling pressures are required, and correspondingly heavier mill housings, etc., although the powers are little or not at all affected. Conventional tin plate work roll diam run between 16 and 21 in. For stainless steel, as an example of hard strip, a $\frac{D}{t_{min}}$ ratio of 500/1 is involved at the lower speed ranges, going up to perhaps 1000/1, for high speed rolling. Thus for 0.010 in. strip, full hard, diam of from 5 to 8 in. are required — no less; although for narrow mills, there is no objection against smaller rolls.

In order to quantitatively study such effects in detail, let us consider a recent case where an old tin plate mill was to be rebuilt into a mill for rolling stainless steels from 0.125 in. down to 0.015/0.025 in. without intermediate anneals. This mill, which was 42 in. wide and had 39 in. back-up rolls, and originally had 16-in. work rolls, was to be fitted with smaller work rolls; and powered from available motors, with a maximum speed selected as 500 fpm. The mill data was substantially as shown at the top of Figure 7. Several rolling schedules were worked through, using D = 16, 12, 10, 8, and 5 in.,

TEST DATA | CALCULATIONS

STAND	DEL. THICK IN.	STRIP TENSION #	STRIP TENSION #/IN.²	DEL. SPEED F.P.M.	ROLLING LOAD P #	L IN.	TOTAL RED. %	$p_{y.s.}$ #/IN.²	$p_{m.y.s}$ #/IN.²	$s_o = 1.155 p_{m.y.s}$ #/IN.²	S #/IN.²	$(s_o - S)$ #/IN.²	PMF	$\frac{\mu L}{t}$ (CURVE)	μ
—	.0910	0	0	—	—	—	0	45,000	—	—	—	—	—	—	—
1	.0662	31,000	15,000	535	1,385,000	.580	27.0	72,000	58,500	67,500	7,500	60,000	1.27	0.46	.067
2	.0395	32,000	26,000	900	1,638,000	.600	56.5	90,000	81,000	94,000	20,500	73,500	1.20	0.36	.032
3	.0272	20,000	27,500	1300	1,310,000	.445	70.0	95,000	92,500	107,000	26,750	80,250	1.17	0.31	.023
4	.0147	16,000	35,500	2400	1,600,000	.462	83.8	98,000	96,500	111,000	31,500	79,500	1.39	0.62	.028
5	.0098	5,300	17,500	3600	1,638,000	.362	89.2	100,000	99,000	114,000	26,500	88,500	1.64	0.92	.081

($31\frac{1}{4}$" WIDE STRIP)

$$L = \sqrt{R(t_1 - t_2) + \frac{16 P R (1-\nu^2)}{\pi W E}}$$

$$PMF = \frac{P}{W L (s_o - S)}$$

Figure 11 — Test data and calculations for μ from Stoltz and Brinks' tests.

to reveal the influence of work roll diam. Figure 7 itself shows such a detailed calculation for D = 5 in., as illustrative of the method described in this paper. The lowest attainable gage for low speed rolling for this diam is 0.012 in., and the schedule shows that it takes 16 passes to reach 0.015 in. It is to be noticed that full front and back tension of 39,000 lb was utilized in all passes down to the 10th, where the tension was decreased, keeping the maximum tension stress at 50,000 psi. After the third pass, the permissible rolling pressure per in. of width ($\bar{p}L$) of 40,000 psi was reached, which continued to be the limiting factor throughout the schedule. This limitation was imposed by the permissible contact stresses between work and back-up rolls, resulting in a total permissible separating force, P, of 1,200,000 lb, which was well under the back-up roll bearing ratings. For the first three passes, mill torque was the limitation, and the schedule could have been revised to decrease the back tension to a minimum value, thus using the front reel for rolling power, in preference to reducing rolling pressure. It is to be noticed how the rolling torque steadily decreases to less than 10 per cent of the initial value, and to be realized that rolling pressure is the limiting factor.

As mentioned above, similar schedules were worked out for five diameters, with results as shown in Figure 12. Now if the mill motors had been connected to the work rolls, rather than the back-up rolls, then still another limitation would have been encountered, namely, the torsional stresses in the work roll necks and spindles; but by shifting to the back-up roll drive, this factor is eliminated from the design. The reason why the smaller work roll mill can take even larger reductions than the larger work roll mill is because of the lesser friction torques involved, which are not shown in our calculations as published herein, but which must not, of course, and cannot be neglected. It is thus seen that a work roll range from say 6 to 10 in. is indicated, and this is the way the mill is being rebuilt.

Questions arise in many peoples' minds regarding the possibility of "lateral bowing" when smaller work rolls are being used. If this matter were carried to extreme, such bowing would certainly occur — but consider the action of the back-up driven mill, in this respect. The torque reaction on the work rolls is to tend to force them rearward, i.e., toward the entry side of the mill, this tendency being the greater in the first passes when full power, and therefore torque, is being applied. Now by using low back tension, as mentioned previously, the front tension exerts a forward force, offsetting the torque reaction, and this balance can be made to be zero, if desired. When the strip is thin, the backward torque reaction is small indeed, thus permitting the use of both high front and back tension, still retaining a null tangential force on the work rolls. Experience has already proved the points made herein. The back-up driven mill, while old in the art, has received increased attention in recent years because of the thin strip problem, and may even hold significant advantages for general cold rolling, as well.

The role of bite friction in the rolling of thin strip has not been heretofore properly and sufficiently appreciated. And particularly the role of higher speeds in reducing such friction. Not counting the value of higher rolling speeds in producing more tonnage, the value of speed in the rolling of lighter gages is comparable in importance to the use of smaller diam rolls. In fact, the rolling of light stainless, say, at 1000 fpm, on a 6-in. work roll mill, is equally as efficacious as a 3-in. work roll at 400 fpm, not to mention the more rugged and simpler construction of such design of 4-high mills.

The importance of tension is a foregone conclusion, in the rolling of thin gage hard alloys particularly. Both front and back tension conspire to reduce rolling loads very materially, and as high tensions should be used as the work hardened strip can properly stand without the danger of tearing from cracked edges and the like. Slight over-rolling of the edge serves to concentrate the tension toward the center of the strip, and reduces the hazard of tearing. The best in reel tension control is indicated, even to the use of regulating tensiometers.

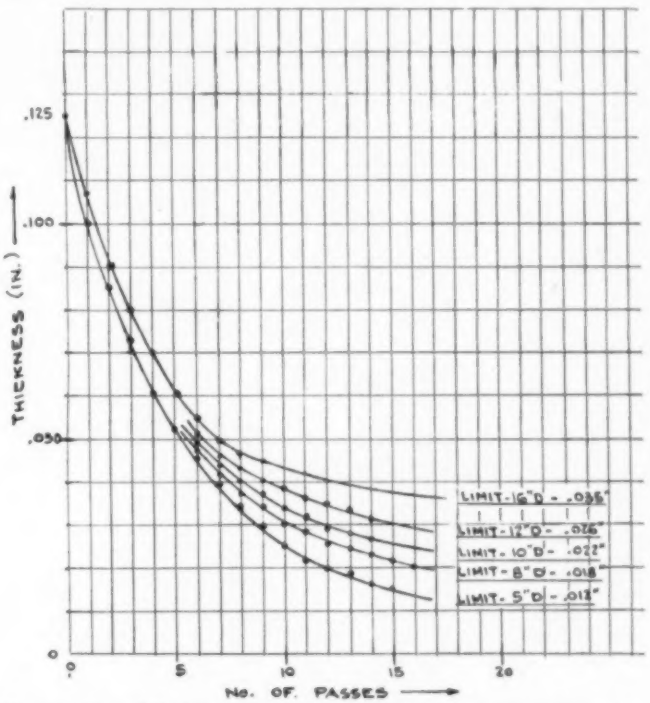


Figure 12 — Minimum thickness vs roll diameter for rolling of stainless steel at low speeds and moderate tensions.

A word can be said about the factor, E, the modulus of elasticity of the work rolls, in connection with thin strip rolling. The only known practical metal having a value of E appreciably greater than the 30×10^6 value for steel, is tungsten carbide, where E may approach twice this value. However, the high cost of such rolls made from this material, and the hazard in manufacture and also use, has made its adoption practically prohibitive other than for "baby" mills, where small diam may be utilized, without the necessity for such high values of E. On the other hand, we see from equation (12), that the use of cast iron work rolls, with an E value of 12/15,000,000 psi would be the wrong material to use, where thin gages are involved.

Let us return to a remark made in the early part of this paper, in regard to the possible use of the energy method in forecasting pass schedules for thin strip. As has by now been appreciated, our calculation procedure not only predicts rolling pressures, but rolling torques as well, which can be converted directly into powers, and energy to roll (hp-hr/ton). A not insignificant com-

ponent in this latter figure is contributed by mill bearing friction and motor losses, and these must be properly added to the rolling torques, T, in Figure 7. As additional evidence of the correctness and accuracy of our theory of thin strip rolling, we have plotted in Figure 13, hp-hr/ton vs gage, these figures being based, it is to be remembered, essentially only on the stress-strain curve of the material being rolled. The conventional semi-log plot is used, with three test curves added to establish the accuracy of the calculated curve. Essential parallelism of the curves is the indication of correctness, and it is evident that such accuracy has been attained. The calculated curve is marked for D = 11 in., since the mill friction losses, which are a considerable per cent of the rolling power, vary with rolling pressure, P, which is a function of work roll diam, D. The data used is the same as that worked up in connection with the study of the influence of D on the rolling of stainless to light gages (Figure 12), and hence several curves of hp-hr/ton vs gage were obtained, one for each diam. If all the points were plotted, i.e., for all diam, and the effect of bite friction were eliminated, then it would be evident that the basic deformation power would be independent of roll diam. However, with roll bite friction included, the mill power to roll can be a major function of diam, particularly for hard alloys, like stainless. And furthermore, when mill friction (i.e. bearing friction, drive losses, etc.) and

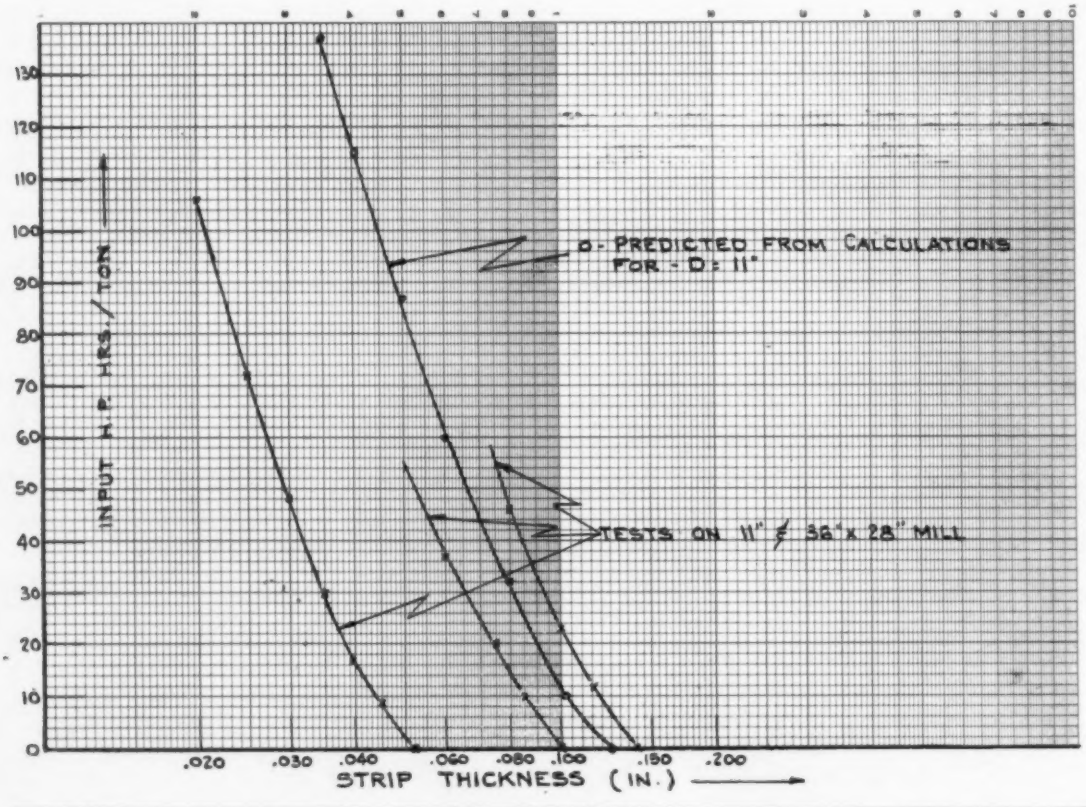


Figure 13 — Energy to roll stainless steel as given by predictions and tests.

motor losses are included, it is even more evident why hp-hr/ton must be referred to a specific diam, as has been done in Figure 13.

As a result of such studies as have been reported here, it can now be appreciated how the small work roll, back-up driven 4-high mill has emerged as the most desirable mill for the high speed production rolling of thin strip. Figure 1, at the beginning of this paper, shows one of two reversing mills in operation at Allegheny-Ludlum, rolling thin hard strip, such as high silicon, stainless steel, and the like, at high speeds. The mills are 6 in. and 34 in. × 30 in., each powered by two 750-hp motors, each motor driving the back-up rolls direct, each reel being powered by two 350-hp motors, the mill speed being 0/800/1600/3200 fpm. Figure 14 is a photograph of one of a line of package mills (complete mills, including motors, reels, coolant and lubrication systems, et cetera, on essentially one base) designed for the finish rolling of thin gage material. The line of mills: 2½ in. and 10 in. × 10 in., 3 in. and 16 in. × 16 in., and 4½ in. and 22 in. × 22 in., are all reversing mills, back-up driven, and have a speed range of 0/2000 fpm. Two mills of the size shown are just starting into operation, one on high carbon steel, etc., and the other on copper alloy strip.

The virtues of this design of mill, in addition to its particular efficacy for thin strip rolling, are: lack of necessity for matching either work roll or back-up roll diam, within quite wide limits; ease of changing work rolls, because of the fact that no spindles need be disconnected; possibility of changing work roll diam, without sacrifice in rolling speed or power, etc. It should be mentioned in this connection that while the work roll diam mentioned above are nominal roll diam, all designs permit variations, which future experience may dictate upward or downward. Because of the advantages cited here, a heavy cold breakdown mill has been designed along the lines developed here, and will be in operation very shortly now. It is a 8 in./16 in. and 53 in. × 56 in. reversing mill, powered by two 1750-hp motors, each reel being powered by two 500-hp motors, the mill having a speed of 0/800/1600 fpm. Others are in the making.

In conclusion, the writer wishes to acknowledge the assistance of Messrs. J. I. Greenberger, A. H. Elgert, Geo. Schmitt, A. B. Cox, and others who have carried

Figure 14 — High speed rolling of thin brass strip at American Brass Co. in 3-in. x 16-in. x 16-in. package mill.

out numerous calculation studies of the type described here, and whose figures were used throughout this paper. We believe that this method of approach has provided the rolling mill designers with an accurate and practical method of handling the difficult problem of thin strip rolling. While not neglecting the innumerable factors that enter into such a rolling problem, the method is yet simple enough to be utilized and carried through without too much tedium. The results of such studies have been the development and adoption of the small work roll, back-up driven 4-high mill as the most suitable for high speed rolling of thin strip.

BIBLIOGRAPHY

1. "*Rolling Pressures in Strip Mills*" by M. D. Stone and J. I. Greenberger, Proceedings of Association of Iron and Steel Engineers, February 1943, presented Sept., 1941.
2. "*Beitrag zur Theorie des Walzvorganges*," von Karman, Zeitschrift fur Ang. Math. u. Mech. 1925.
3. "*Die Formgebung in Bildsamen Zustand*" — book by E. Siebel — 1932.
4. Series of articles in Blast Furnace and Steel Plant, by W. Trinks, particularly March and June 1937.
5. A.S.M.E. publication "Roll Neck Bearings" — 1935.
6. "*The Calculation of Roll Pressure in Hot and Cold Flat Rolling*," by E. Orowan, Institute of Mechanical Engineers, 1943, sponsored by B.I.S.R.A.
7. "*A Theoretical Investigation of Roll Flattening*," by D. R. Bland, Institute of Mechanical Engineers 1950, a B.I.S.R.A. report.
8. "*The Forces Required for Rolling Steel Strip Under Tension*," by A. Nadai, Journal of Applied Mechanics (A.S.M.E.) June 1939.
9. "*Roll Pressures in Rolling Steel Strip*," by J. D. Keller, Steel, September 1942.
10. "*Researches into the Deformation of Metals by Cold Rolling*," by H. Ford; "*The Calculation of Roll Force and Torque in Cold Strip Rolling with Tensions*," by D. R. Bland and H. Ford, Institute of Mechanical Engineers, April 1948; "*Cold Rolling Techniques*," by H. Ford, 22 serialized articles in Sheet Metal Industries starting with July 1948 issue.
11. "*The Rolling of Metal*," by L. R. Underwood, a series of 39 serialized review articles running from February 1945 to May 1948, in Sheet Metal Industries. Also rewritten for book "*The Rolling of Metals*,"John Wiley & Sons.
12. W. Lueg and A. Pomp — Mitt. der K.W. Inst. fur Eisenforschung — 1935, pp 63-76.
13. "*Coefficient of Friction and Flow in Strip Rolling*," by W. Trinks, Blast Furnace and Steel Plant, July 1937.
14. Report to B.I.S.R.A., quoted in Underwood's book Reference (11), pp 154 to 163.
15. "*Lubricants for Cold Rolling*," by R. J. Nekervis and R. M. Evans, Proceedings of Association of Iron and Steel Engineers, 1948.
16. "*Cold Rolling of Tin Plate*," by G. E. Stoltz and J. W. Brink, Proceedings of Association of Iron and Steel Engineers, 1950, pp 654-673.
17. "*Friction*," by T. E. Stanton, p 150.
18. "*The Cold Rolling of Mild Steel Sheet and Strip*," by A. Hays and R. S. Burns, Blast Furnace and Steel Plant, November 1936.
19. "*Einfluss Des Haspel-und Bremzuges auf den Kaltwalzvorgang*," by W. Lueg and F. Schultze, Stahl u. Eisen, December 26, 1940.
20. "*High Speed Tensile Tests*," A. Nadai and M. Manjoine American Society for Testing Materials, 1940.
21. "*The Effect of Speed of Rolling in the Cold Rolling Process*," by H. Ford, Journal of the Iron & Steel Institute, July 1947.
22. "*How Thin Can Strip be Rolled?*," by J. D. Keller, Blast Furnace and Steel Plant, October, 1937.

DISCUSSION

PRESENTED BY

JOHN H. HITCHCOCK, Director of Research, Morgan Construction Co., Worcester, Mass.

R. L. STOCKUS, Sales Manager, Armzen Co., Waterbury, Conn.

M. D. STONE, Manager, Development Department, United Engineering and Foundry Co., Pittsburgh, Pa.

John Hitchcock: I regard this paper as a noteworthy contribution to our knowledge of the cold-rolling process. The evaluation which is presented in this paper of the coefficient of friction between material and rolls, is especially welcome. We have known for a long time that such friction plays an extremely important role in the limitations of the cold rolling process, but we have not previously had valid figures to associate with this effect, particularly concerning the variation of this friction coefficient with speed.

Following the suggestion made a couple of years ago to which Morris Stone referred, that the changes in thickness of strip accompanying changes in mill speed were attributable in large part to changes of thickness in the oil film, we undertook a rather ambitious research program to measure the oil film thickness together with other pertinent factors, through the kind cooperation of the U. S. Steel Corp., who made a mill available for this purpose. This work has not been completed. It probably will be reported on in detail at some later meeting of the Association of Iron and Steel Engineers. From results now available, however, we can say definitely that the variations in oil film thickness are insignificant in magnitude from the standpoint of their effect on strip thickness, confirming the result which Morris Stone presented in his paper. He showed that the variations in strip thickness with changes in mill speed arise primarily from the conditions in the roll bite and specifically from the variations in coefficient of friction between material and rolls with changes in speed.

R. L. Stockus: I would like to comment briefly on three phases of the subject: theory, operations, and economics. The theories presented are more or less fundamental, and I think we can say that they have been verified by actual test data. I am speaking of conventional mills using relatively large rolls. I want to offer a word of caution, however, in entering the field of small rolls. So many things are happening so rapidly; with new roll materials, new finishes and new lubricants. Our friends in the oil business, as you know, are making great strides and you have seen them dump a gallon of sticky stuff in the lubrication system and change rolling conditions completely. In a few years we should have enough factual data on the behavior of small rolls. We are now building two mills with ¼ in., work rolls and have on paper a mill with 0.1 in. work rolls.

From an operating point of view, small work rolls

have many advantages. We build about 10 different types of sendzimir mills. However, at the moment, the "work horses" are of the 1-2-3-4 type, with either 1½ or 2-in. work rolls. This design allows widths up to 80 in., and driving four of the six outside rolls permits us to transmit enough torque to take advantage of the reducing ability of the small roll.

To show you how a 1½-in. roll compares in reducing ability with the 5-in roll which Dr. Stone has discussed, I have a rolling schedule, taking 36-in. wide 18-8 stainless steel from 0.125 to 0.015 in. in ten passes. Assuming an 8000-lb coil, the total feet rolled is 18,000. I made a hurried calculation of the number of feet in the 16 pass schedule, and the total footage is 36,000. The point here is that with a 1½-in. roll, the same job can be accomplished in either half the time or at half the speed. This particular mill is under powered. We are now building mills for stainless steel with speeds up to 800 fpm. We have low carbon mills up to 1500 fpm. If we think back to the progress we have made in the past 3 years, in reaching speeds of 400 fpm and taking 20 per cent reductions on wide stainless, I think it is reasonable to say that two years from now I can come back and show you that we are running at 800 fpm and taking 20 per cent reductions.

Small rolls also give the advantage of extremely high accuracy. The coil I just discussed above had a total variation of 0.017 initially. You all know that the only thing that irons out inaccuracies is the rigidity of the mill. With small rolls, the roll separating force is small. Also, our mill columns are very short, which decreases the springiness.

Using small rolls as we do makes the operator the complete master of strip surface. It is almost amusing at times to watch the helper walk over to a rack and pick up two 40-in. rolls, one on each shoulder, and walk over to the mill to make a change.

The most important advantage of small rolls, however, is in the over all economics. First, the mill itself is much smaller. We are now building a mill for 80-in. wide auto body sheets. The mill housing weighs 105 tons. I would guess that the weight of a conventional mill of the same width would be three times that. Incidentally, Dr. Stone, I would like to ask you a direct question here. Would you say that a 5-in. roll would be possible in your mill in widths over the 30-in. mill you discussed?

Installation costs are much lower, because foundations are lighter. Light cranes permit lighter buildings. Small rolls also require smaller roll grinders. Even our largest mill can be adequately supplied by a $30,000 grinder. My guess is that a grinder for a conventional mill would be in excess of $100,000.

Small rolls permit small roll inventories. For example, a 40-in. mill for producing stainless at the rate of 1500 to 2000 tons per month would need a roll inventory of about $50,000.

The fact that we eliminate anneals and pickles means less processing equipment, which in turn means less time in process for the material.

M. D. Stone: The writer is pleased to have Mr. Hitchcock's comments, as his contribution to the theory of cold rolling in evaluating the effect of roll flattening in simple form, has been a major starting point in the current study. As to the effect of change in oil film thickness in an oil type mill bearing, as influencing strip gage, current knowledge seems to point in other directions for a possible explanation of change in gage with speed.

Mr. Stockus' comments seem to be concerned with the thesis that small or ultra-small work roll mills are the answer to the rolling of all thin metals. This, of course, is far from the case. For high production, low cost rolling of metals, the optimum mill design and work roll size is that which will permit maximum reduction, compatible with no thermal distortion of rolls, at the high speeds. For aluminum foil, for example, with gages going down to 0.0003 in., 50 per cent reduction per pass and 98 per cent overall reduction without intermediate anneals can be taken with work rolls 8 to 10-in. diam, at speeds of 3000 fpm and over. For tin plate, involving gages down to 0.007 in., long roll life and trouble free operation at speeds exceeding 5000 fpm dictate work roll diam from 15 to 21 in. For harder metals, however, such as the stainless steels, the high carbon steels, etc., smaller work rolls are advantageous, and work rolls of from 2½ in. to 6 in. indicate great efficacy in rolling of stainless down to 0.005 in. at speeds in excess of 1500 fpm without intermediate anneals. For ultra-thin stainless strip, say down to 0.001 in., the writer will agree with Mr. Stockus that even smaller work rolls are probably to be preferred.

A case in point of misapplication of small work roll mills of the type Mr. Stockus is talking about has to do with a mill having 2-in. diam work rolls, installed to roll low and medium carbon steels from 0.090 to 0.015 in. as a production item. While this mill was capable of making the reduction in four passes, the operator varied the pass schedule to evaluate roll costs, maintenance costs, etc., vs production for a 5-pass, 6-pass, 7-pass, and an 8-pass schedule, and ended up with a 7-pass schedule on this mill as the most economical. This same product is being rolled on standard 4-high mills in two plants, one having a 10-in. diam work roll and the other, a 12-in. diam, one utilizing a 5-pass schedule and the other a 6-pass schedule (for improved surface finish), at production costs more than $5 per ton less than for the ultra-small work roll mill.

The author would like to comment further on the actual calculation procedures in carrying through the numerical evaluation of the theories established in this study. As mentioned in the paper, the most accurate (but somewhat tedious) procedure to date has been to use the trial-and-error method outlined in the tabulation given in Figure 7. Of course, plots of families of curves of the type shown in Figures 8 to 10 inclusive would shorten the work considerably, but would result in a somewhat confusing maze of lines. Mr. Frank Dahlstrom, who has been intrigued with the subject for some time, has worked out a calculation board based on these relationships, which greatly decreases the time consumed in carrying through the calculations. For some time, the author has investigated various types of nomographic chart methods, but in each case, the accuracy of the results was not too good, in that small differences between large quantities were always involved. Recently, however, a new type of nomographic chart has been hit upon which satisfies all requirements adequately, and reduces the time required to carry through the calculations to a fraction of that required heretofore. (This will be published later.)

AUTOMATIC CONTROL FOR REGENERATIVE SOAKING PITS

By GRIFFIN L. ISAACS
Assistant to Superintendent
Blooming Mills
United States Steel Corp.
Duquesne, Pa.

. . . . automatic control on the pits improve quality, reduce maintenance and scale loss, and increase production. . . .

▲ INCREASED production throughout the steel industry has resulted in many plants having inadequate soaking pit capacity. Even before the recent increase in production, a number of primary mill operators were seeking improved pit performance to cope with the increasing demand for high quality carbon and alloy steel. Although this condition has caused mill delays, the production loss is often too small to justify the expense of new pits, but it is too large to be neglected. The only alternative to constructing new pits is to improve existing facilities.

Such a condition prevailed at Duquesne where the twelve banks of regenerative pits offered an excellent opportunity to increase heating rates by using automatic controls. For the trial installation, a four-hole furnace was chosen. Each pit is capable of heating a maximum charge of six 25-in. square ingots on its 5 ft 3 in. × 8 ft hearth. The mixed coke oven and natural gas, with a heating value of about 700 Btu per cu ft, is introduced by two 1½-in. pipes, located in each checker roof. Air and flue gas cannot be controlled independently, because each pair of pits is serviced by a single flue. This furnace, like most old regenerative soaking pits, has an abundance of air when the checkers are new; but as the checkers become contaminated with cinder and flue dust, the volume of air is restricted so much that the maximum firing rate must be reduced. This condition usually begins after a few months of service, and becomes progressively worse until the checkers have to be cleaned or renewed. To minimize this effect of variable checker conditions, forced draft equipment was proposed to supply air at a steady rate. However, the control of the air-fuel ratio for each hole is not practical because the common flue arrangement cannot be changed without costly alterations.

The possibility of soaking without dampering was considered so that air could be supplied continuously to permit independent operation of each pit. Doubts were expressed concerning the desirability of this procedure, as an excess quantity of air was likely to cause higher fuel rates and greater scale losses. Also of primary concern was the chilling effect of the 70,000 cu ft of free air that would cross the pit each hour. The heat absorbed by the excess air would amount to 9.8 per cent of the normal fuel rate; but better combustion, as the result of adequate air supply, would more than pay for this heat loss. Furthermore, the continuous air system

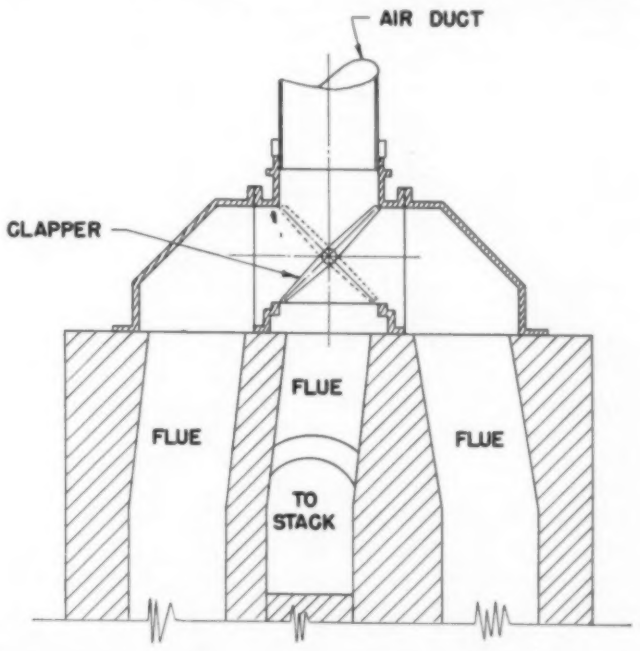


Figure 1 — Flue reversing valve was designed to accommodate the existing arrangement.

would allow firing during the soaking period, which would result in reduced heating time. Scale loss was not a major problem, since old regenerative soaking pits usually have enough air infiltration during the soaking period to provide an oxidizing atmosphere. The chilling effect of excess air soaking could not be disregarded, but it was found that reversing the checkers rapidly with the air duct open would equalize the pit temperature as well as if the pit had been sealed by dampering.

When it became apparent that the advantages of continuous air firing outweighed the disadvantages, work was begun on the installation of such a system. The two D-slide type reversing valves, with their hydraulic cylinders, were replaced by two air-operated clapper valves. No structural or flue changes were necessary because the cast iron valve bodies, shown in Figure 1, were designed to accommodate the existing flue arrangement. This first step would not be necessary for pits having the mushroom, sliding-gate reversing system, but the air mushroom valve would have to be equipped with forced air ducts, and the flue gates would have to be operated by an electric motor or air cylinder.

The next step in the trial installation was to provide a method of mechanically reversing the fuel. The gas manifolds supplying the front and back burners were equipped with air operated butterfly valves. Spring-loaded, diaphragm-type motor operators were installed to reverse the gas valves. Thus far, mechanical equipment had been provided to reverse the air, fuel and flue gas. To coordinate this equipment, an automatic reversing cabinet was installed. It contains two timing units for cycle control so that the time of firing can differ from side to side. The cycle timer reverses the three-way clapper valve, and sets a second timing unit in motion that closes the gas butterfly valve on the firing side and permits necessary interval for flue reversal before opening the other gas butterfly valve. A schematic diagram of this equipment is shown in Figure 2. Both of the automatic timing devices have controls to adjust the reversing cycle and the time of gas lag.

The new automatic reversal system with forced air provided rapid checker reversals and stronger convection currents, which resulted in better heat distribution within the pits. The ability to maintain the desired pit temperature contributed to a faster heating rate. The heating rate was evaluated by comparing the ratio of heating time to transit time before and after the improvement. Before the improvement this ratio was 1.98. After the improvement it was 1.48, which is a gain of 25 per cent. A comparison of fuel rate per ton with another row of pits that had checkers of similar condition displayed an improvement of 11 per cent. During the fuel comparison period, each bank of pits had 30 per cent of its checkers inactive.

Along with these encouraging results came some adverse effects. First of all, the heaters were not able to consistently control the proper amount of fuel during the soaking period. Too much gas caused minor washing of the port ingots, and not enough gas caused loss of pit temperature. The tendency was for the heaters to revert to damper soaking. The need for maintenance increased because high temperatures were obtained too rapidly for proper control by the heaters. The occasional high temperature coupled with increased ingot scale made bottom maintenance difficult. Cinder line erosion required frequent patching of division walls and bridge walls. On the occasion when three holes were fully charged, and the fourth hole was empty, gas was supplied at full throttle to all four holes for nearly 30 minutes. The extremely high temperature of the empty pit caused two courses of checker brick to melt and flow into the flue. When this bank of pits was taken out of service, solid cinder, instead of ordinary red flue dust, was found in the flues. The red dust usually found in regenerative flues is largely Fe_2O_3, but this rock-like cinder was mostly Fe_3O_4. The logical explanation was that the red flue dust had been reduced by a combination of coke breeze carry over and extremely high temperature. Five days were required to remove this rock-like mass from the narrow, horizontal flues.

The 25 per cent increase in heating rate was sufficiently promising to warrant a concerted effort to obtain proper control of pit temperatures. To properly control temperature manually was impossible because the heating value of the gas varied from 640 to 735 Btu

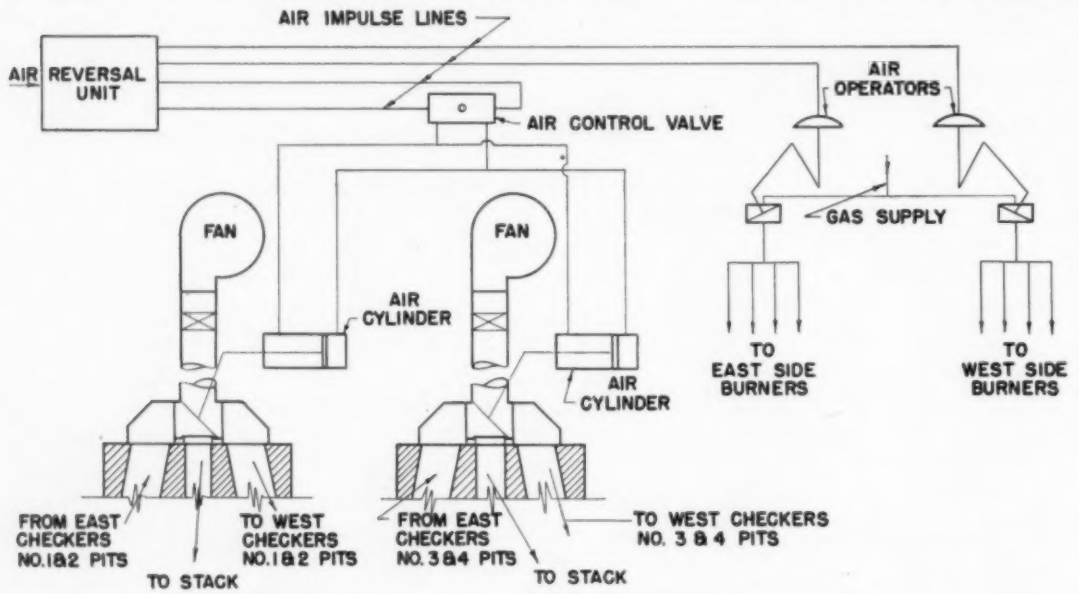


Figure 2 — Schematic diagram of automatic reversal system.

per cu ft within a single hour. Also, when the fuel to one bank of pits was increased or decreased, the line pressure would change so that the valve position could not be used as an indication of flow rate. With these variations in gas flow, the only practical way to control temperature is by automatic gas throttling.

There were many good temperature control systems on the market that could have been used for this installation, but they could only control temperature at the point of measurement. Therefore, a great deal of consideration was given to thermocouple location. The checker roof was considered as a possible location, but it was disregarded because calibration would be required to obtain an indication of ingot temperature and because excessive fluctuation of the impulse would result from flue reversals. The pit wall above the arch was also considered, but this location was abandoned because the thermocouple would have to pass through two beams and 30 inches of brick. The location selected was at the center of the pit cover since it was in the vicinity of the ingots and would be only slightly affected by flame impingment or air infiltration.

A suitable apparatus was devised to transfer the thermocouple impulse from the movable pit cover. This device is shown in Figure 3. It is composed of a piston encased in a seamless tube. One end of the piston rod is fastened to the pit cover and the other end is fitted with two insulated copper bars. When the cover is on the pit, the piston rod is extended and the short copper bars make contact with two spring-loaded brushes. The thermocouple lead wires are located inside the hollow piston rod and are connected to the copper bars. The impulse is taken from the stationary brush contactors.

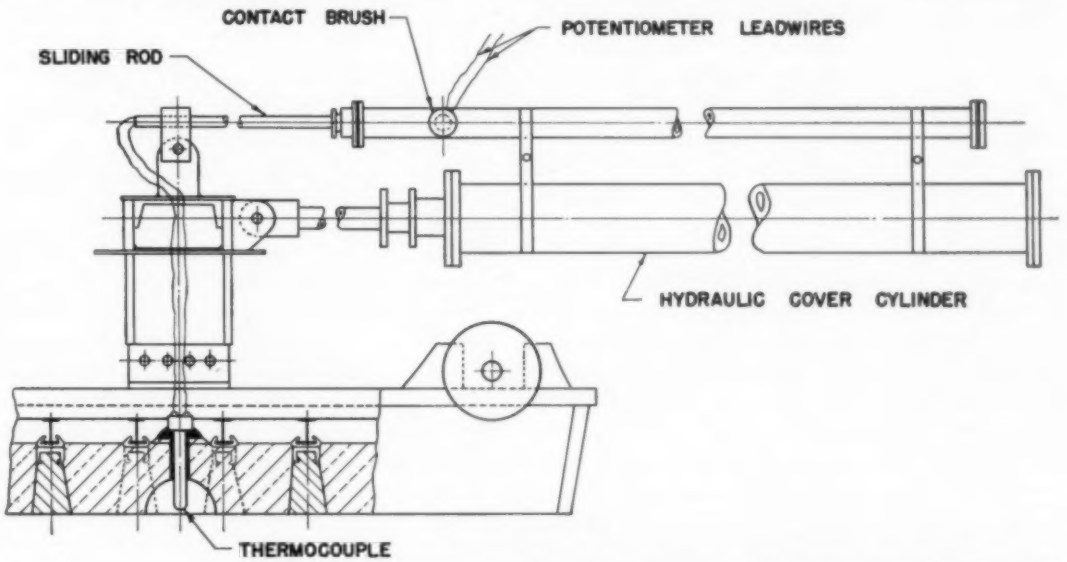


Figure 3 — This apparatus was designed to transfer thermocouple impulse from the movable pit cover.

The complete assembly is mounted on the hydraulic, cover-operating cylinder with strap-like pipe clamps.

Before the installation of automatic temperature control, one hole was equipped with a strip chart potentiometer to determine the difference between ingot and thermocouple temperatures. Ingot temperatures taken with an optical pyrometer were 200 F higher than the recorded temperature during the heating period and 150 F higher after the ingots had soaked. This temperature difference was reduced by increasing the diameter of the thermocouple well from 8 to 10 in. The temperature difference, after normal soaking, then varied from plus to minus 25 F. This was considered satisfactory, since the temperature difference continued to decrease as soaking time increased.

After the satisfactory experience with the trial potentiometer recorder, all pits of this row were equipped with automatic temperature controls. Standard equipment was used except for the impulse transfer device. Each pit was operated independently by an electronic strip chart potentiometer that received its impulse from a platinum-platinum rhodium thermocouple element, as shown in Figure 4. Air controls were used on three pits and electric control on one pit to provide a basis for comparison. The air controls were not as fast as electric controls, because of deposits from the coke oven gas which frequently caused the butterfly valve to stick when the system was operating within the proportional band. For example, the instrument might furnish 10 psi to change the valve position from fully open to one-half open, but the valve would stick and cause the pit temperature to exceed control temperature. Air pressure would then increase until the valve would finally close. Positive positioning equipment can be furnished by most instrument manufacturers to minimize this condition. No comparison regarding relative maintenance costs has been determined because of insufficient experience to date.

By referring to Figure 4 it can be seen that a single pit required two control valves. These butterfly valves were linked together so that the movement of one valve would cause the same movement of the other valve, so that only one motor was required to control the gas flow to east and west burners. The automatic reversal cabinet and potentiometer controllers were placed on a single panel as shown in Figure 5. This enabled complete control from the panel while heating most grades of steel. Alloy steel with low thermal conductivity required adjustment of the manual plug valves to limit the heating rate, but even this manual control can easily be eliminated by having program heating equipment built into the controller.

The ratio of heating time to transit time was again evaluated and found to be 1.36. The total increase in

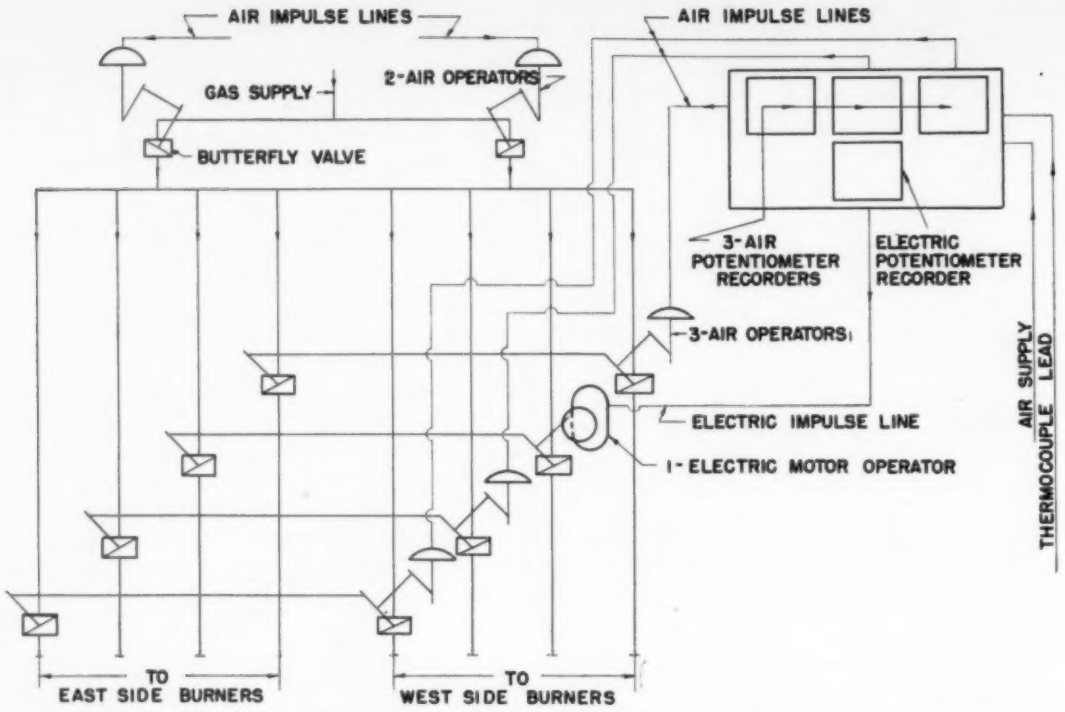
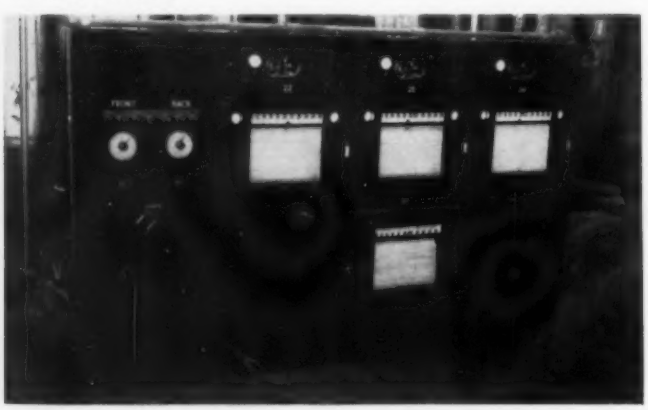


Figure 4 — Automatic temperature control system.

heating rate on this basis was 31 per cent, but this figure must be qualified because of the variation in checker condition. When the ratio of 1.98 was determined — with no control — the soaking pits were new, but the ratio of 1.36 was displayed by the same pits 17 months later. At that time the checker flues were more than 50 per cent restricted, so the 31 per cent decrease in heating time does not reflect the entire improvement. It should also be noted that heating gain decreased as transit time decreased. In fact, no improvement is shown with ingots having a transit time of 45 minutes or less, as little or no heating is required. The average transit time during the above study was 3 hours 18 minutes.

As expected, less coping and cinder line maintenance was required by the automatically controlled pits, and the formation of solid cinder in the flues was eliminated. Heating quality was also improved by better distribution of heat and elimination of excessive temperatures. Scale loss was greatly reduced, because thermal shock was minimized, and the heavy oxidizing scale would not fall off in the pit. In short, the automatic controls herein described were desirable in every respect.

Figure 5 — Panel controls a 4-hole regenerative soaking pit furnace.



DISCUSSION

PRESENTED BY

FRED S. BLOOM, President, Bloom Engineering Co., Pittsburgh, Pa.

G. H. KRAPF, Assistant Chairman Fuel and Power Committee, United States Steel Corp., Pittsburgh, Pa.

H. H. DINNEEN, Chief Engineer, Rust Furnace Co., Pittsburgh, Pa.

V. A. KNIPE, Combustion Engineer, Bethlehem Steel Co., Bethlehem, Pa.

H. V. FLAGG, Combustion Engineer, Armco Steel Corp., Middletown, Ohio.

W. H. DAILEY, JR., Surface Combustion Co., Toledo, Ohio.

F. C. McGOUGH, Superintendent Fuel and Power, Detroit Steel Corp., Portsmouth, Ohio.

CHARLES M. FITZPATRICK, Assistant Superintendent Blooming Mills, Bethlehem Steel Co., Sparrows Point, Md.

RUSSELL M. WEIGLE, Assistant Superintendent Rolling Mills, Bethlehem Steel Co., Steelton, Pa.

GRIFFIN L. ISAACS, Assistant to Superintendent, Blooming Mills, United States Steel Corp., Duquesne, Pa.

HERBERT G. MILLER, Coordinator Material and Process, National Tube Division, United States Steel Corp., Lorain, Ohio.

Fred S. Bloom: It might be well to state that I had a lot to do with the method which was selected to improve this regenerative pit operation. I think the history and the reason back of this job is worthwhile considering. We have throughout the steel industry in the United States a great many old regenerative pits.

As you know, these pits are normally constructed in a row of four holes to a block with a common air supply and common stack flue to the four holes collectively. This means that there is no way to control air supply to any individual hole. This type of soaking pit is considered obsolete as compared to the modern recuperative soaking pit, but many existing installations still have considerable useful life providing the difficulties of this type pit can be overcome without too much capital expenditure.

As we reviewed the problem of obtaining modern operating practice from old regenerative pits, it seemed to us that we should be able to improve pit capacity, if we could burn more fuel which meant that we had to supply more air to each individual hole. Also, if we increased fuel burning capacity, we had to do something to correct the normal fault of the regenerative pit — being that of port marking. And further, if we were going to obtain modern operation, we had to find a means for applying pit temperature control.

In conjunction with engineers from the United States Steel Corp., we investigated the practice on regenerative pits and also on modern one-way fired pits. We found that in general the regenerative pit could heat as fast, if not faster than the modern recuperative pit; however, the quality of heating on high Btu fuels was faulty due to washing and port marking which we attributed to the fact that the regenerative pit was operated by hand control method, which could not be expected to compete with a good system of temperature control. We also thought that if the reversing cycle could be greatly shortened then the opportunity for port marking could be minimized.

It was, therefore, decided to set up a program of experimentation and to try to see what could be done by installing equipment to supply more air to the pits, so that more fuel could be burned and to reverse the pits as fast as necessary to eliminate port marking. We knew that the basic system of coke oven gas installation at Duquesne works was comparable with anything we could think of, because a great many good fuel engineers had worked on this problem. We felt that they had tried everything which was reasonably possible to improve a combustion process by proper location of the gas pipes. We also felt that since the present system of air supply to the four holes of the regenerative pit gave no method of controlling air supply to an individual hole, the supply of additional air could do us no damage.

We, therefore, proceeded to install forced air to give us approximately twice the amount of air normally supplied to this bank of pits and we put in a time cycle reversal control unit to reverse the operation of the pit as fast as possible. The time cycle for reversal was adjustable but we soon found that good results could only be obtained from reversal cycles of approximately two minutes duration. This method allowed us to eliminate port marking, because we were not burning fuel sufficiently long on one side to build up high enough temperature to port mark the steel. Thus, we had accomplished a major point in proving that the old regenerative pit could be made to heat quality steels.

As soon as we had overcome the port marking, we immediately found that with increased use in fuel per unit of time and with the increased amount of air supplied, the pit became too fast for manual control. Previous experience at the Duquesne works had indicated that measuring pit temperature and transfer of this measurement to controlling instruments was a difficult job, due particularly to the arrangement of the pit covers, and also to the fact that the ingots were often carried over the wires which lead to the temperature control thermocouple. We decided to at least try to eliminate this difficulty by constructing a very rugged telescoping device so that the thermocouple lead wires would be protected. This device has worked, and with its use we have been able to get good pit temperature measurement and control without undue maintenance. The results that were accomplished are well explained in Mr. Isaacs' paper. What we have done is to construct the regenerative pit combustion system for an arrangement of constant air input regardless of fuel input. This means we have an oxidizing condition around ingots when they are hot. We make no attempt to regulate air supply to the individual hole. This gives us a simple means of temperature control since all our temperature instrument has to do is regulate gas input. We set our stack damper in a fixed position and do not attempt to change this position.

We have no arguments to offer that fuel/air ratio and automatic furnace pressure control would not be an advantage in this particular installation or with many similar types of installations. The cost of installing pressure and ratio controls are almost prohibitive, not because of the cost of the controllers themselves, but because of the changes in regenerative pit structure which would be necessary.

We think by the simple method of approach which has been taken that the useful life of a regenerative pit can be prolonged and can be arranged to give comparable quality heating results with those of the modern recuperative soaking pit.

G. H. Krapf: I would like to bring out one more point for you who might wish to think about using this idea. That is, you cannot get faster heating unless you have increased gas input. The idea of rapid reversal was to use the much higher gas input and still not burn the ingot, but remember that because the pit is reversed about every two minutes, the off time is very much more than a pit that is reversed every fifteen minutes, so you must compensate in two ways for the time the fuel is off. One is to make sure your actual reversal is very fast, in the neighborhood of seven or eight seconds; and secondly, that you put in during the firing time a corresponding increase of gas to compensate for the extra time out. In addition, you must put in extra gas to accomplish the faster heating that you started out to get.

H. H. Dinneen: The modernization of old regenerative soaking pits often presents difficult problems. The application of automatic control equipment described by Mr. Isaacs is about all that can usually be accomplished without the expenditure of a considerable sum of money.

Pits that have more than one hole connected to a common flue eliminate the possibility of individual pit pressure, fuel air ratio, and reversal control. These controls, we feel, are essential to obtain the maximum performance from a regenerative pit. Forced draft air and automatic temperature control for each pit are also essentials. Maximum fuel in-put and program control

are two functions which may be incorporated with the temperature control. In some cases these items are of value, and at other times they are not necessary. In this particular case where high quality carbon and alloy steels are being heated we feel that their use would be justified. In view of the flue limitations of the pits in question, we feel that Mr. Isaacs has made the best of a difficult situation. However, while the modernized pit shows decided improvements over the old, we feel that a comparison with a modern pit would reveal the possibility of further savings, particularly in regard to capacity, fuel consumption, and heating quality.

There is another conversion possibility, namely, to convert two small holes to one large one. The battery described has one flue for each two holes and it is sometimes possible to join the two small holes into one large one, thereby overcoming the lack of sufficient flues. A conversion such as this involves new covers, possibly new cover mechanisms, and other associated work. It also makes possible a conversion which may approach the best regenerative pit design. I would like to ask Mr. Isaacs if this possibility was given consideration.

In conclusion, we would like to point out that the high quality carbon and alloy steels being heated in these pits require the utmost in heating quality. In addition, there is insufficient capacity with the resultant necessity to drive the pits. When these factors and the type of pits are considered, I believe that a remarkable job is being done in obtaining satisfactory performance.

V. A. Knipe: Mr. Isaacs has presented an informative paper on one of the big problems faced by those steel plants where space limitations require that soaking pit heating capacity be increased by improvement to present facilities. Bethlehem was also faced with the same problem, and also realized that the installation of automatic control equipment was an answer to increased efficiency, the obtaining of better quality of product, and increasing heating capacity to keep pace with increasing production demands.

Many trial installations and tests indicated that individual pit controls would produce better results. On this basis we have installed additional regulation and instrumentation over and above that mentioned in Mr. Isaacs' paper.

The pits which were improved are used primarily for structural steel heating, and are the old regenerative type, each hole being 12 ft 9 in. × 8 ft 6 in. × 10 ft 0 in., and having a hearth area of 108.38 sq ft. Each pit has two checker chambers and two flues. This pit is the result of the combination of two smaller holes to aid in setting up individual pit control and providing more hearth area. The fuel used is mixed coke oven and blast furnace gas with a heating value of 130 to 135 Btu per cu ft. The mixing takes place at the furnace in order to provide the heater with better control of heat input. Prior to changes in pit firing the only items automatically controlled were gas pressures and reversal time, and the only instruments were gas flow meters recording the total flow to twenty-two pits. With this set-up there was no means of determining and correlating gas flow, combustion air, pit temperature, pit pressure, or Btu content of the mixed gas to the individual pit.

It was felt with all these variables involved in soaking pit operation, heating capacity could only be increased by additional instrumentation and regulation to control individual pit performance.

With these factors in mind, the following equipment was added to each pit system: (1) pit-pressure regulator with manual remote loader; (2) pit-pressure recorder; (3) coke oven gas-air ratio regulator; (4) blast furnace gas-air ratio regulator; (5) temperature recorder with high limit control; (6) coke oven gas flow control meter with manual or automatic control; (7) blast furnace gas flow control meter with manual or automatic control.

Since this system was installed in 1949, soaking pit heating capacity and efficiency have shown a marked improvement. This improvement, when compared with the old-type pits before modernization amounts percentage-wise to about:

Tons per pit per hour	12.0+
MBtu per ton	28.0—

The results obtained by the installation of automatic controls at the Duquesne works, as pointed out by Mr. Isaacs, and at Bethlehem, indicate that they are an answer to increased soaking pit heating capacity.

H. V. Flagg: I do not think there are any of us who have been interested in steel mill combustion for the last twenty-five or thirty years, who have not faced this particular problem at one time or another. Some of us have made attempts to work out improvement, but I have never heard of a completely satisfactory solution of the problem of applying temperature control to cross-regenerative pits. The trouble has always come from two causes, first, as both Mr. Isaacs and Fred Bloom have pointed out, from the lack of facilities for regulation of the air, and second from the difficulty of obtaining temperature measurements.

My interpretation of Mr. Isaacs' paper is that they have put a constant supply of air across the pit, and then have increased or reduced the fuel to maintain the temperatures in the pit according to the requirements as shown by a control pyrometer. At first thought, the scheme appears impractical, but on reflection it becomes evident that elimination of the need for air regulation makes the application of temperature control fairly simple. Certainly the idea is well worth thinking about, especially since Duquesne has been able to make it work. I would like to know what type thermocouple is used? With temperatures as high as 2400 F, it strikes me that a rare metal couple is indicated unless the radiation pyrometer or some comparable device is employed. How much trouble have you had maintaining couple in operation, and what has been the cost of couples? Have you ever lost a pit full of steel because a thermocouple went bad on you? Finally, the question that interests us all, how much did you have to spend to make the installation?

W. H. Dailey, Jr.: It strikes me that two of the points at least are just as important for the most modern pits as they are for regenerative pits. First, I heartily concur with Fred Bloom when he states that when temperature control does not operate satisfactorily you might as well abandon it. I think that a large part of the improvements that have been made on the most modern new pits are due to improved methods for accurate measurement and control of the temperature.

Another point that occurs to me as being parallel is the desirability for fast operation of fuel and air valves. In modernized regenerative pits the reversal uses up

time which would normally be used for heating steel, and consequently during the remaining time when the fuel and air is on, the fuel input has to be increased.

Now a somewhat similar situation has risen in the last few years on the very large modern pits where in many cases the charge weight is a hundred fifty tons on the average, and the time required to roll it is of the order of thirty minutes to fifty minutes. The time required to open a cover, draw an ingot, close the cover, and restore the fuel, is of the order of a minute for each ingot. To maintain the temperature of the ingots during rolling, provision must be made to bring the fuel and air on very rapidly when the cover is closed, and frequently the fuel input must be increased over the normal maximum.

F. C. McGough: I get the impression that if the money were available and the pits were adaptable to the installation of furnace pressure control that it would not be considered. Is that correct, Mr. Bloom?

Fred S. Bloom: I will agree with you a hundred per cent. If you can do any good with furnace pressure, I certainly recommend it.

F. C. McGough: On the basis that the areas of the regenerators decrease by fifty per cent, I cannot understand how you can always be assured of optimum furnace pressure conditions throughout the entire campaign of the block, without some means of control.

Fred S. Bloom: We have not seen any difficulty with furnace pressure. Due to the fact we do blow a constant volume of air into the pit, we can set our stack damper at a fixed point; and, therefore, there is no reason for automatic furnace pressure control being in the picture. From a study of our results on existing installations, I do not believe we could save too much by the installation of furnace pressure control. When you talk about putting a furnace pressure and ratio control on the regenerative pit, possibly you are talking about rebuilding a large part of the flues and valve mechanisms in order to make such an installation possible. If you wish to do this, it is entirely satisfactory, but we cannot see how we can recommend the expenditure of at least $100,000 per row of four holes of soaking pits to accomplish a savings of five per cent. We have pretty well demonstrated that we can get good quality operation with a speed equal to or better than that obtained from the recuperative pit with the expenditure of very little money. The reversal control, temperature control, and fan installation is less than $10,000 per hole.

G. H. Krapf: Our cost is closer to $5000 a hole on the average on these installations, for our experience on applying this idea on holes is somewhere in the neighborhood of $5000–$7000.

Charles M. Fitzpatrick: Would the author give us information on bottom making practice?

Russel M. Weigle: Can you give us some information on the fuel rate for these pits?

Griffin L. Isaacs: Mr. Dinneen asked if there had been any thought placed on making one hole out of two holes, in other words, making a larger pit. Mr. Knipe covered that very well, and as far as we are concerned we certainly are thinking about it. That would do away with excess air firing, and we could go to furnace pressure at low cost.

Mr. McGough asked a question about furnace pressure. When first installed, the thermocouples occasionally gave low readings because negative furnace pressure caused air infiltration in the area of thermocouples. This was corrected by causing the furnaces to "blow" slightly.

In answer to Mr. Flagg's question, the type of thermocouple we used was platinum-platinum rhodium. As far as maintenance of the thermocouple, we had absolutely no trouble. We were told that we would probably have trouble due to the mechanical working of the couple by the vibration caused by the pit cover moving off and on the pit. That was not true. The vibration evidently was not great enough to fatigue the couple.

Now the cost of equipment was discussed, and just to clarify it in everybody's mind, the cost without forced draft fans was $17,500 for the complete job (4 holes). That is without engineering expense.

Now you probably noted from the paper the method used in developing this equipment. It was by other people's experience and trial and error. Now I presented it, in the way it was done. There was no engineering expense on this. Now with forced draft fans it would probably go about $20,000, still without engineering expense.

Mr. Fitzpatrick, what did you have in mind as to bottoms?

Charles M. Fitzpatrick: The frequency that you might have to open the bottoms, and the regularity with which you would add coke.

Griffin L. Isaacs: Normally every forty-eight hours is our ideal.

Charles M. Fitzpatrick: I am thinking in terms of how frequently the bottoms have to be opened?

Griffins L. Isaacs: We open the bottoms each time we add coke.

H. V. Flagg: Is your bottom making any different now than it was on the old pits?

Griffin L. Isaacs: Absolutely no different. As I mentioned in the paper, it was different without temperature control because we would build up a heavy oxidizing scale, and then blast the ingot with gas again. This would shock the scale and it would fall off. With this heavy oxidizing atmosphere, we would make another one right away. Now I am not qualified to say how many scale coats we made, but there was quite a bit. The advent of temperature controls eliminated that, practically, because we made one heavy scale for the most part and held that scale.

H. V. Flagg: How much fan, and what static pressure do you have?

Griffin L. Isaacs: About 3 in. of water. That we do not pay too much attention to, because we cannot do anything about it if we did because of the common flue arrangement.

H. V. Flagg: How much cold steel do you have?

Griffin L. Isaacs: That is about two per cent, but more important than cold steel is the quantity of hot top. That will probably be interesting to you. It certainly affects this answer. Our hot top ranges from 35 to 40 per cent.

Mr. Krapf asked me if I am saying that the fuel rate is much higher than our continuous air pit. As I mentioned before, theoretical calculations show that we require 9.8 per cent more fuel than a normal method of

damper soaking. That is not true in the overall picture because we get better combustion of the fuel, and at the same time we put more heat into the ingot, because there is a strong convection current at all times passing across the pit. We no longer have stagnant soaking, and do not seal the pit off and soak it in a stagnant atmosphere. So there is better heat transfer.

If any of you were sufficiently impressed to try this system, I would like to warn you, first of all, to take a look at your transit time. If you are charging ingots with molten centers, you cannot realize much improvement from this type of installation.

Herbert G. Miller: Is the positive pressure critical? If it is, what limits do you aim at?

Griffin L. Isaacs: I cannot talk in terms of quantities of pressure. It simply means this, that if you do not have furnace pressure you get air infiltration, and when you get air infiltration you are materially affecting the top of your ingot and the thermocouple reading. When that happens your thermocouple is reading colder than the pit temperature. You wind up in the extreme case with cold tops and melted bottoms. That is as far as we are concerned with pressure. Too much pressure we do not care much about unless the flame is traveling so high in the pit that the ingot bottoms get cold.

G. H. Krapf: There are those who have not worked with this method of heating who might see troubles arising in regard to the use of it. We, too, saw the same troubles when we decided to put the method into effect. Fortunately most of them did not materialize.

This furnace pressure discussion indicates that a simple setting of the damper by hand, so that a reasonable blow is obtained out of the cover, is sufficient for maintaining good control.

Scale loss was another item that we were afraid of, when operation with continuous air was being considered. Neither did this materialize, since in reviewing the method of operating these old soaking pits, it was found that it is impossible for the heaters to charge the four holes in a row of pits all the same with the same kind of steel. They would have some pits charged with colder steel and some pits charged with comparatively hot steel. This caused unequal gas flow to each hole, and the air supply to the row had to be enough for maximum gas being used. It is not possible to control air flow to each individual hole, so even the normal heating practice meant that ninety per cent of the time the heater was firing his pit with full air. There has been no additional provision made for scale loss on steel heated in these holes, and as far as I can find out there has been no evidence of an additional scale loss in the practice of the mill. In other words, the scale losses in the mill practice are just as good out of this pit, if not a little better, than out of the old pits. We do find on these temperature controlled pits that we do make a good scale that will clean easily on the mill, and we do not find the secondary scale underneath that has a tendency to give difficulty on rolled-in product. Is that right?

Griffin L. Isaacs: That is right. One thing I failed to mention in that connection, this heavy oxidizing scale is an insulating coat, and it materially adds to quality heating.

Plan to Attend

1953

AISE SPRING CONFERENCE

HOTEL STATLER

BUFFALO, NEW YORK

MAY 18, 19

AND

1953 ANNUAL CONVENTION

HOTEL WILLIAM PENN

PITTSBURGH, PA.

SEPTEMBER 28, 29, 30, OCTOBER 1

EFFECT OF LUBRICANT ON GEAR PERFORMANCE

By V. N. BORSOFF
Research Engineer
and
S. S. SOREM
Research Engineer
Shell Development Co.
Emeryville, Calif.

. . . . gears should be designed to operate in the thick film zone of lubrication . . . .

▲ DURING the past three decades automotive, aviation and industrial gear design has shown a consistent trend toward lighter weight, heavier specific loading and higher speed. As a natural consequence of this trend, gear lubricants, which have the multiple duty of cooling, preventing scoring, reducing friction, and minimizing wear have been improved to keep pace with gear design. The improvements thus far have consisted primarily of the introduction of extreme pressure agents to increase the load that can be transmitted without scoring, extensions of the fluidity range, improvements of stability and prevention of corrosion and foaming. Since the trend toward more severe operating conditions, especially in the aviation field, shows no sign of slackening, extensive research is being continued to meet the requirements of the gears of tomorrow.

These operating conditions can be summarized as follows: extremely high speeds, high specific loads and wide temperature ranges. Even now, speeds over 20,000 fpm, loads, expressed as Hertzonian pressure, of over 150,000 psi, and temperature ranges extending from −60 F to +600 F are being considered. It is the purpose of this paper to discuss the steps being taken to provide gears which will operate under these extreme conditions with particular reference to lubrication.

Many of us are accustomed to thinking of gears as highly reliable and efficient power transmitting mechanisms. This attitude is justified by an almost complete absence of gear problems in the machines with which most of us have day-to-day contact. However, when an attempt is made to reach the maximum economy of weight and materials as we must, particularly with airborne equipment, a number of potential problems arise. Some of these problems will be initially evident as gear failures. Others will first appear as operational disorders which if not corrected will lead to gear failures or some other maloperation of the unit. These are listed in Table I.

GEAR FAILURES

Gear failures are subdivided here into six main classes: (1) tooth breakage, (2) pitting, (3) scoring, (4) abrasion, (5) chemical wear, and (6) corrosion. It is true that the literature recognizes many more types of gear failures. The American Gear Manufacturers Association for example lists twelve[1]*. However, these more detailed subdivisions include descriptions of conditions resulting from a combination of causes and of secondary effects initiated by some primary failure, and are omitted here.

Tooth breakage is a mechanical and fatigue phenomenon, depending on the magnitude of the load, the number of cycles, strength of the materials and the tooth form. In designing for tooth strength, the Lewis equation is generally used. Pitting is primarily a surface fatigue phenomenon and also depends on magnitude of the load, number of cycles and the strength of the

TABLE I

Possible Problems of an Overloaded Gear Set

Gear failures	Operational disorders
1. Tooth breakage	7. Overheating
2. Tooth pitting	8. Foaming
3. Scoring	
4. Abrasion	
5. Chemical wear	
6. Corrosion	

*Superior numbers refer to bibliography at the end of the paper.

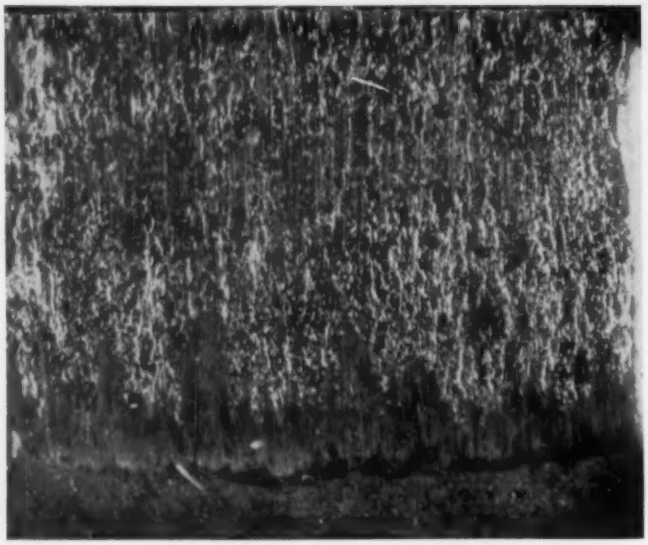


Figure 1 — Illustration shows pure scoring on a tooth with a Rockwell C-hardness of about 62. Magnification is about 15X.

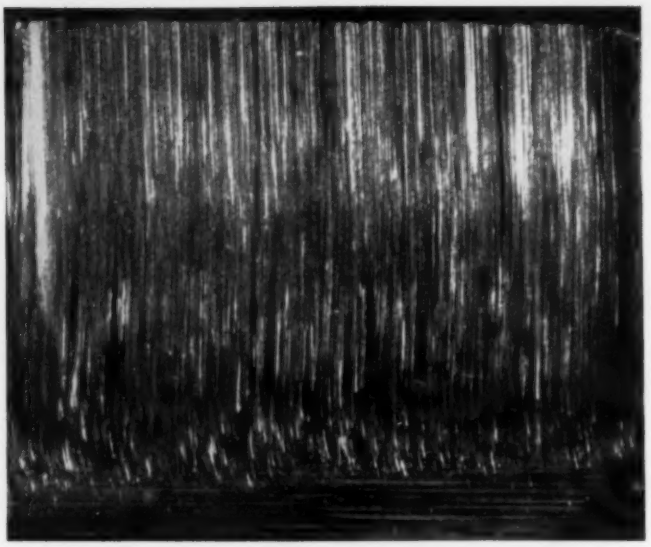


Figure 2 — Illustration shows pure abrasion on a tooth with a Rockwell C-hardness of about 62. Magnification is about 15X.

materials. It has been found that to some extent pitting can be alleviated by shot-peening[2] and by operation with more viscous lubricants[3]. Apparently a thicker lubricant film prevents heavy stress concentrations and so minimizes pitting.

Abrasion and scoring are surface phenomena and represent a failure of lubrication. The lubricating film must have broken down, at least partially, to make these failures possible. Since the descriptions of these failures in the literature are rather vague it is desirable to explain how these terms are used here.

An example of scoring (frequently also called scuffing) is given in Figure 1. The surface shown is the addendum of a tooth of a used gear enlarged to about 15 diameters. Note that the very top layers of the metal have melted and have then been smeared over the neighboring area. The surface shown in Figure 2 represents an example of wear by abrasion. Here the surface appears plowed, i.e., metal was removed by a mechanical process probably similar to that of cutting in a lathe. Abrasion takes place when the lubricating film is too thin to prevent the cutting action of projecting asperities, but is too strong to be displaced and permit scoring.

Chemical wear is encountered when extreme pressure type additives are used in a lubricant to counteract scoring. These additives function by reacting with the metal of the gear tooth surfaces to form a protective film less readily displaced than oil. However, when this film performs its function a portion of it is lost by attrition and is replaced by further reaction. This loss and replacement of the film gives rise to chemical wear. In most cases, chemical wear is too slow to affect gear performance within the normal life of equipment. However, this is not always true. The case of case hardened gears sometimes becomes thin enough, as the result of chemical wear, to permit distortion due to flow of the underlying softer metal. Failures called "rippling" or "fish scaling" are of this type.

MECHANICAL METHODS FOR IMPROVEMENT OF GEAR PERFORMANCE

The study of these failures reveals that both speed and load affect them all adversely. It is therefore the aim of gear designers to design gears for a given operating condition with minimum sliding velocity and with the lightest possible specific load. Earlier gears were inaccurate, they "cogged" and "jammed," i.e., they transmitted motion in an irregular, jerky manner, and the teeth were subjected to dynamic loads in addition to the transmitted torque load. To overcome this, many forms of conjugate gear tooth action were developed. The involute form is the most extensively used today. From the standpoint of kinematics, which deals with motion only and excludes the concept of force, the involute form is ideal since it maintains a constant angular velocity ratio between mating gears. From the standpoint of tooth contact pressure and rubbing velocity, it leaves much to be desired. With the involute form, the sliding velocity is zero at the pitch circle and increases sharply toward both the addendum and dedendum. To minimize its maximum value the gear designer chooses the smallest possible tooth that will carry the required load. The smallest possible tooth is also desirable from the standpoint of the tooth contact pressure which depends on the radius of curvature and increases with the distance from the pitch circle. To some extent the load at the point of highest sliding velocity is further decreased by tip relieving the addendum and undercutting the dedendum. Still, on an involute profile, conditions are most severe on the addendum and dedendum as shown by the fact that scoring and other wear failures almost invariably occur first at these points. The load also depends on the contact ratio, which in the present designs with straight gears is usually less than two. This means that the transmitted torque for a part of the time is carried by one pair of meshing teeth only. The contact ratio is sometimes improved by employing oblique designs.

The unfavorable effect of speed and load does not end with the variations along the active profile. With production gears operating at high speeds, the irregular transmission of motion, though not so obvious, is still a factor to be considered in determining the total load acting between gear teeth. We are accustomed to thinking of load as that caused by the transmitted torque.

This is the so-called "applied" load. On top of that there are "additional" loads caused by tooth deflection and various inaccuracies and errors, such as run-out error, pitch error, profile error, etc. These additional loads, according to Professor E. Buckingham[4] vary as the square of the velocity and at high speeds they reach dangerous proportions. A high degree of accuracy in manufacturing is the only possible relief from these loads. The American Gear Manufacturers Association[5] specifies tolerances for class 4 gears (over 2000 fpm) up to 0.0002 in. For the gears of tomorrow, operating up to 20,000 fpm, even finer tolerances may be required.

Other mechanical approaches which have resulted in improved gear performance are improvements of gear material, heat-treating processes and surface finish. Generally, manufacturing gears from tougher and stronger materials will result in better preservation of geometry and surface finish. Comparison of the materials used in the past with those used today verify the above. Regarding surface finish, the general tendency is toward a high degree of smoothness. Collins[6] advocates high surface finish, one effect of which is to spread the load more uniformly over the contacting surfaces, thus minimizing peak loads at asperities.

Operational disorders can also be alleviated by mechanical means. In the case of overheating, Collins has shown that surface finish is an important factor in the production of heat. Much can be done also in the removal of heat by providing an excess of lubricant to act as a coolant.

Foaming problems can frequently be eliminated by rearrangement of the lubricant circulating system to minimize the mixing of air with the lubricant and by providing separators to aid in the removal of air that does become entrained.

There are, however, practical limits to the improvements which can be made in gear accuracy, geometry, material and finish. For example, it is hard to visualize a gear set being cut, assembled and operated without some tooth errors in excess of 0.0001 in. Thermal and mechanical strains and wear of supporting shafts, bearings and structure practically prohibit going further mechanically. Thus for further progress the job of maintaining satisfactory operation and preventing failures must be assumed by the lubricant.

LUBRICATION AS A FACTOR IN IMPROVING GEAR PERFORMANCE

In the history of gears there are examples where lubricants literally saved the situation. In the twenties hypoid gears were developed. Notwithstanding the advantages they offered, particularly for automotive applications, they were at first considered unoperative because of the scoring that inevitably resulted upon application of their design load. The introduction of extreme pressure lubricants saved these gears, and now loads from 10 to 20 times those obtainable with uncompounded lubricants are successfully carried.

Most of the improvements in gear lubricants to date have been the result of a qualitative approach to the chemical and physical-chemical problems involved. To produce films less readily displaced than hydrocarbon oils for the purpose of extending the region of boundary lubrication, three approaches appeared theoretically possible: (1) the addition of polar compounds which would be adsorbed on the gear teeth; (2) the addition of unstable materials which would decompose and deposit a tenacious film under gear tooth conditions (leaded oils); or (3) the addition of compounds containing chemically active ingredients such as chlorine, sulphur or phosphorous (EP oils) which would react with the gear tooth surface forming a lubricating film in situ. All of these approaches have been effective in some applications. The first two have been found best suited to bronze on steel worm gears where they give very appreciable increases in load carrying capacity. For heavily loaded steel-on-steel gears, the chemically active extreme pressure oils are the more successful. Many of these compounds gave extraneous reactions in use, leading to corrosion, deposit formation and rusting. Various test procedures had to be set up to detect these potential difficulties and eliminate offending materials. A number of such test procedures will be found listed in the MIL-L-2105 gear lubricant specification.

The effect upon the lubricant of overheating has been reduced by suitable selection and treatment of the base lubricant, by the use of oxidation inhibitors and, more recently for special application, by the replacement of mineral oil base materials with synthetics of considerably greater stability. This has been strictly a chemist's problem.

Foam, although of mechanical origin, has been greatly minimized as a gear lubrication problem by the introduction of additives which reduce the stability of foam once formed.

Corrosion problems have been taken care of principally by avoiding additives that produce corrosive materials by undesirable side reactions though a number of buffers and corrosion inhibitors are known and used.

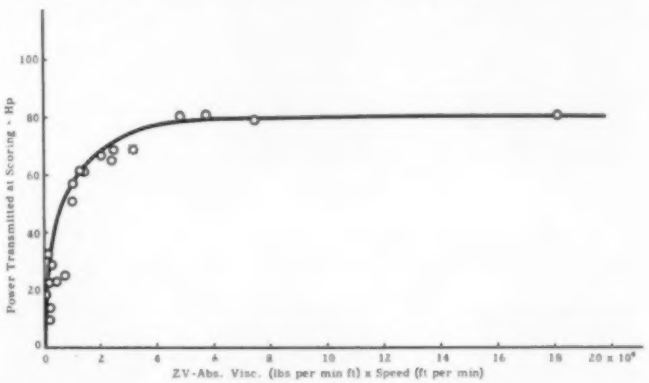


Figure 3 — The horsepower transmitting capacity of test gears as limited by scuffing is given by this curve.

All together these mechanical and lubricant improvements have resulted in tremendous strides in the art and science of power transmission through gearing. However, much further progress appears possible. To facilitate this progress, quantitative information relating the power transmitting capacity of a gear set to the physical and chemical characteristics of both the gear and its lubricant is needed. As a first step in this direction the mechanism of gear lubrication must be thoroughly understood.

Classical lubrication mechanism studies with steady state systems, such as a journal bearing, show the

existence of two zones of lubrication, called the hydrodynamic and the boundary zones. In the hydrodynamic or thick film zone, a film of lubricant exists sufficiently thick to prevent contact of even the highest asperities of the rubbing surfaces. The film pressure integrated over the bearing area is equal to the total load and can

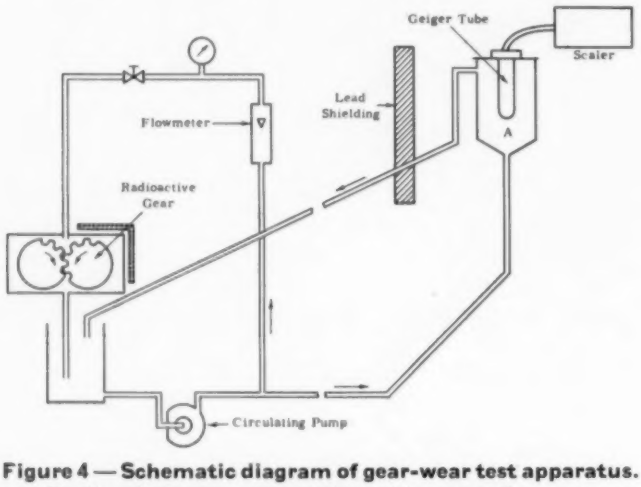


Figure 4 — Schematic diagram of gear-wear test apparatus. Radioactive gear was used in this research.

be calculated for these simple systems. In this zone of lubrication, friction is low and wear is virtually absent because of the absence of contact between metal components. When the load exceeds that which can be supported by hydrodynamic pressure, lubrication is said to be in the boundary or thin film zone. A portion of the load is now carried on films formed by adsorption or reaction of some constituent of the lubricant on the metal surfaces. Lubrication in this thin film zone gives rise to higher coefficients of friction and to some wear.

In what zone of lubrication do gears operate? There are two schools of thought on this subject. One believes that gears operate in the boundary zone of lubrication and that formation of thick film is unlikely[7] [8]. The other recognizes thick film lubrication in the regions of light loads and believes in the possibility of extending thick film lubrication to extremely high loads[9] [10] [11]. To decide which of these two theories is correct, it would be necessary to know precisely the tooth contact pressure and the supporting hydrodynamic pressure, neither of which is readily determined on meshing teeth. The contact pressure is the sum of the transmitted torque and dynamic forces which are functions of speed and the deviations from the perfect tooth form resulting from errors and deflections. The supporting hydrodynamic film pressure is a function of speed, fluid viscosity and density, and the shape of the surfaces forming the film boundary. Fluid properties vary with pressure and temperature, and the film boundaries may be significantly affected by elastic and thermal distortions and profile errors. Because of the interdependence of so many variables and the cyclic nature of the meshing gear system, the mathematics describing the conditions of gear tooth lubrication become extremely involved even with many simplifying assumptions. While several attempts have been made along this line[10] [11] the authors have preferred an empirical approach.

In their initial work, which has been previously published[12], the scuffing limited horsepower transmitting capacity of test gears was established as a function of speed and lubricant viscosity for a series of straight mineral oils.

The curve in Figure 3 shows this relationship. Operation under any condition represented by a point above the curve resulted in scoring. Operation under conditions below the line gave no scoring or measurable wear. The fact that oil viscosity, at the temperature of its application, appeared to be the only significant lubricant variable and absence of wear below the curve were strong indications that this area represented the region of hydrodynamic lubrication. However, a conclusion

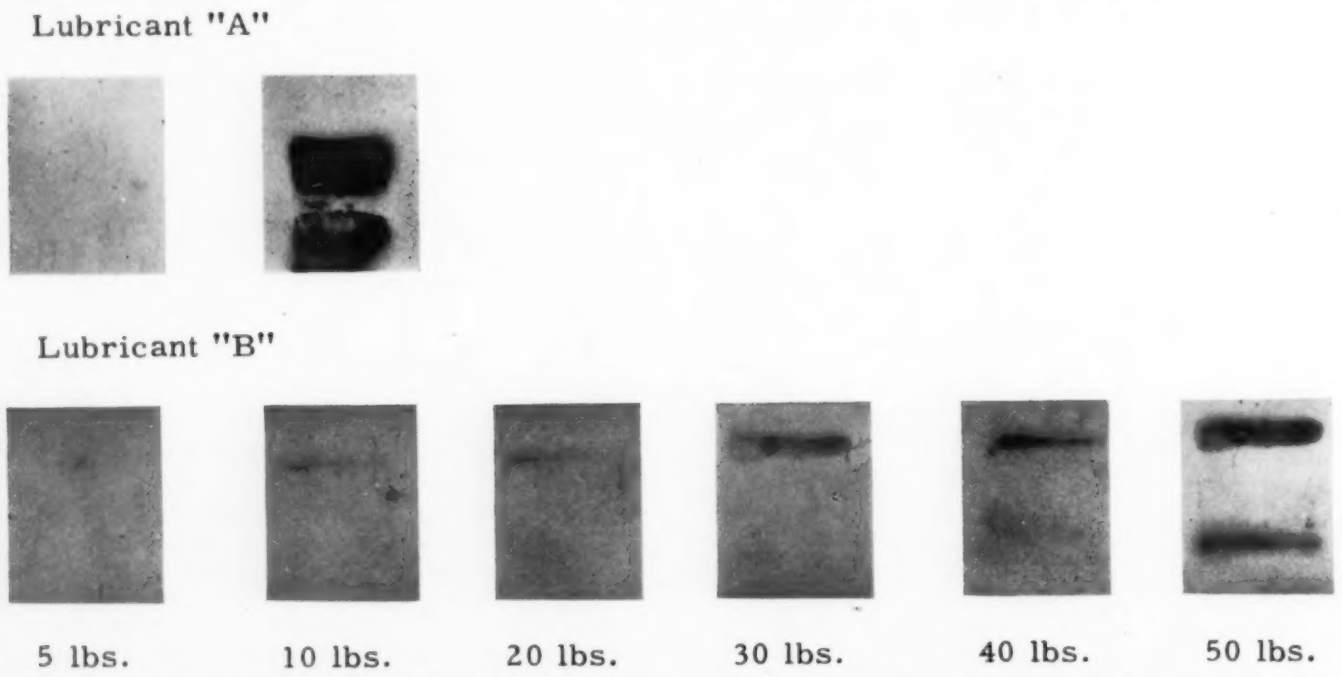


Figure 5 — Radiographs of working teeth surfaces of inert gears show radioactivity picked up by this gear.

to this effect was considered questionable, particularly since the visual method of gear tooth inspection then used was unable to distinguish between a gear tooth surface which had been protected by a thick film, and one which had been protected by a boundary film. It was obvious that new research techniques were required to resolve even this fundamental question; in what zone of lubrication do gears operate? Radioactive tracers have provided an answer to this question, and in addition have been found extremely useful in the study of gear wear in operations with chemically active lubricants.

RESEARCH WITH RADIOACTIVE TRACERS

The apparatus used in this radioactive tracer work was built around the same "four square" gear test unit used in the previously mentioned investigation[12]. The only modifications required were the substitution of a radioactive gear for one of the test gears, a revision of the lubrication system to include instrumentation for the measurement of radioactive particles in the oil, and the addition of shielding and other equipment for reduction and detection of radiation hazards.

The general set-up is shown in Figure 4. The gears used were seventeen and nineteen tooth spur gears of six diametral pitch, 20 degree pressure angle and ¼ in. face width. They were made of SAE 3312 steel, case hardened to 62 RC, and ground with an unmodified involute profile to approximately AGMA Class 4 tolerances.

The seventeen tooth gears, weighing about 150 grams each, were made radioactive by 30 days neutron bombardment in an atomic pile at Oak Ridge. Their activity (15 days after removal from the pile) was about 250 MR per hour at one foot. The average half life over the 30 to 60 day period was 90 days. Fe^{59}, Cr^{51}, and Co^{60} were the principal contributors to be measured radiation.

To determine the state of lubrication which exists under given conditions of gear operation, advantage is taken of the fact that metal transfer takes place between surfaces separated only by a boundary film. When one surface is radioactive, the metal transferred during a period of operation under boundary conditions of lubrication may be detected on the inert surface by its activity. Figure 5 shows autoradiographs made by exposing a photographic film on the surface of the teeth of an inert gear after it had been run against a radioactive gear. Oil A was a mineral oil which under the conditions of test, according to Figure 3, permitted initial scoring at 10 lb beam load. The radiograph shows no indications of metal transfer below the scoring load. Oil B in the same figure illustrates the behavior of the same oil with an EP agent added. Although a condition of scoring was not reached with this oil, metal transfer occurred at the same load as without the additive, and the areas of boundary lubrication are clearly shown.

To make wear measurements a portion of the oil from the lubrication system was circulated through a chamber where a Geiger tube connected to a scaler unit was mounted. Lead shielding around the gear box and between the gear box and the chamber protected the Geiger tube from excessive amounts of direct radiation from the gear. In order to establish a relationship between scaler count and the quantity of wear products from the radioactive gear in the oil, a tooth broken from an active gear was made into oil soluble metal naphthenates. Portions of this material containing known weights of gear metal were then added to oil in the circulating lubricant system. By this means the calibration curve, Figure 6, was obtained. In making wear calculations from the counter data, it was necessary to subtract the average background count from the count obtained, correct this value for gear activity on the day of test relative to its activity on the day of the calibration run and then obtain the wear value corresponding to this corrected count from the calibration curve.

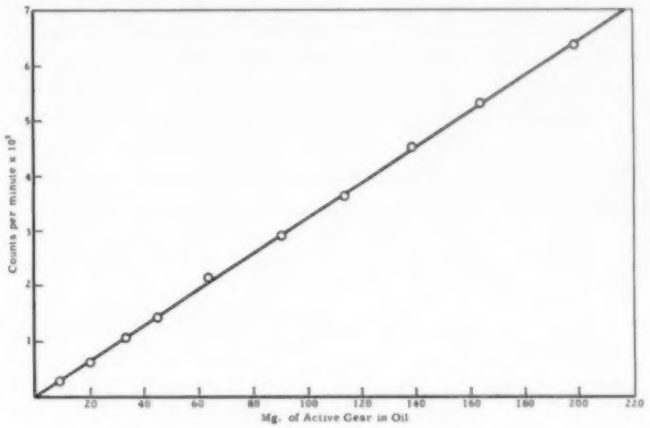


Figure 6 — Calibration of Geiger counts in terms of active gear.

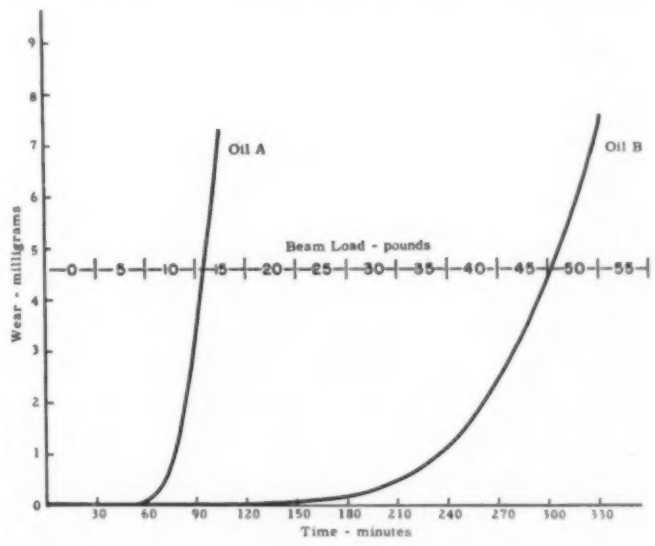


Figure 7 — Curve shows wear versus time and load for radioactive gear experiments.

Monitoring of the oils in the tests previously discussed gave no indications of the presence of wear particles, Figure 7, at any load below the hydrodynamic limit. With oil A, the evidence of wear particles in the oil was coincident with the first visual evidence of scoring. With oil B some chemical wear was to be expected as soon as

operation proceeded into the boundary zone. This was no doubt the case, but the magnitude was too small to be detected until somewhat higher loads were reached. Even then, the wear rates were low compared with those encountered when visible scoring occurred.

The above results indicate that gears, when lubricated with a straight mineral oil, operate in the thick film zone of lubrication up until the score load is reached. These results also show that gears lubricated with oils compounded with EP agents also operate in the thick film zone up to the score limits of their base oils, and that loads above this score limit are carried by a chemical adsorbed film typical of boundary zone of lubrication. Since operation in the thick film zone of lubrication offers many advantages, as smaller friction, lighter pitting and practical elimination of wear, both gears and gear lubricants should be designed to operate in the hydrodynamic zone of lubrication as a goal of ideal operating conditions.

While the results thus far do not provide the gear designer with an equation into which he can plug values of gear and lubrication variables and work out a gear transmission giving a 100 hr, 1000 hr or 10 year life, it has resulted in the development of research tools which will permit substantial progress in that direction.

BIBLIOGRAPHY

1. "*Gear Tooth Wear and Failure*," anonymous, Machinery Vol. 52, April 1946, p. 166-169.
2. "*Shot Blasting to Increase Fatigue Resistance*," by J. O. Almen, SAE Journal Vol. 51, July 1943.
3. "*Lubrication and the Load-Carrying Capacity of Gears*," by E. T. Hutt, Presented at the ASLE National Convention, Cleveland, April 1952.
4. "*Spur Gears*," by Earle Buckingham, McGraw-Hill Co. 1928, Chapter VIII.
5. "*Gear Tolerances and Inspection*," American Standards Association, B6.6-March 1946.
6. "*Developments in Gear Design and their Lubrication Requirements*," by L. J. Collins, presented at ASTM Symposium on Lubrication of High-Speed Turbine Gear Equipment, February 14, 1949.
7. "*Measurement of Temperature Flashes on Gear Teeth under EP Conditions*," by H. Blok, proc. of the General Discussion of Lubrication and Lubricants, London, October 1937, Vol. 2.
8. Discussion by E. A. Ryder, Transactions of the ASME, Vol. 73 No. 5, July 1951, p. 694-695.
9. "*Hydrodynamic Theory in Gear Lubrication*," by A. Cameron, Gear Lubrication Symposium of the Institute of Petroleum, February 1952, part I, page 1.
10. "*The Effect of Variation of Viscosity with Pressure on the Load Carrying Capacity of the Oil Film Between Gear-Teeth*," by Even McEwan, The Institute of Petroleum, Gear Lubrication Symposium, February 1952, part I, page 33.
11. "*Non-Steady State Load Supporting Capacity of Fluid Wedge-Shaped Films*," by E. K. Gatcombe, Transactions of the ASME, Vol. 73, No. 8, Nov. 1951, p. 1065.
12. "*The Effect of Oil Viscosity on the Power Transmitting Capacity of Spur Gears*," by V. N. Borsoff, J. B. Accinelli and A. G. Cattaneo, Transactions of the ASME, Vol. 73, No. 5, July 1951, p. 687.

DISCUSSION

PRESENTED BY

L. J. COLLINS, Gear Engineer, Medium Steam Turbine, Generator and Gear Department, General Electric Co., West Lynn, Mass.

M. S. HOUGH, Lubrication Engineer, United States Steel Corp., Clairton, Pa.

L. J. Collins: I was fortunate enough to be able to visit the Shell Development Co. in Emeryville, Calif. in May of 1952. What impressed me most during my visit to the laboratory and again while reading the paper is the fact that here is a new tool. This tool and the method of applying it took a great deal of study and considerable courage. Through the use of the test procedure as outlined in the paper, man can obtain answers now in a matter of hours which would have required years previously.

Melvin S. Hough: It is gratifying to learn that sometime in the future our gear designers may be able to tell us what life span a gear transmission has under a given load using a certain type of lubricant.

It was interesting to learn from the test using radioactive tracers that we do have protection at times with thick film lubrication. With production increasing daily, I wonder if the gearing in industry ever has a chance to operate normally with this thick film lubricant. The test definitely showed that an extreme pressure lubricant, although metal transfer occurred at the same load as a straight mineral oil, would prevent scoring and the chemical wear was nil as compared to wear rates when scoring occurred using a straight mineral oil. Some gear manufacturers are reluctant to approve the general use of so-called E.P. gear oils in their equipment. I am wondering if a similar test were made using an oil containing polar agents or fatty oils.

In closing, I would like to say that most of our gear failures in industry today are not due to improper lubrication, but are caused by overloading, overheating, improper alignment, shock, loose bearings, or deflection of shafts or housings.

S. S. Sorem: In answer to Mr. Hough's question with regard to polar agents, we have not as yet run an oil containing only a polar additive in the radioactive tests. However, we have run load carrying capacity tests with such oils in which we have made visual observations of scoring. With a highly polished steel gear tooth surface, the contribution to scoring resistance of just a polar agent is very small as compared with the contribution of the chemical active extreme pressure agents.

WANTED!

There is a constant demand for copies of "The Modern Strip Mill", published by the Association of Iron and Steel Engineers.
If your copy is not in use please get in touch with us.

ASSOCIATION OF IRON AND STEEL ENGINEERS, 1010 EMPIRE BUILDING, PITTSBURGH 22, PA.

INERTIA STUDIES FOR MODERN MILL DRIVES

By T. B. MONTGOMERY
Engineer-in-Charge
Control Design
Allis-Chalmers Mfg. Co.
Milwaukee, Wisc.

and

J. F. SELLERS
Assistant Chief Engineer
Motor and Generator Section
Allis-Chalmers Mfg. Co.
Milwaukee, Wisc.

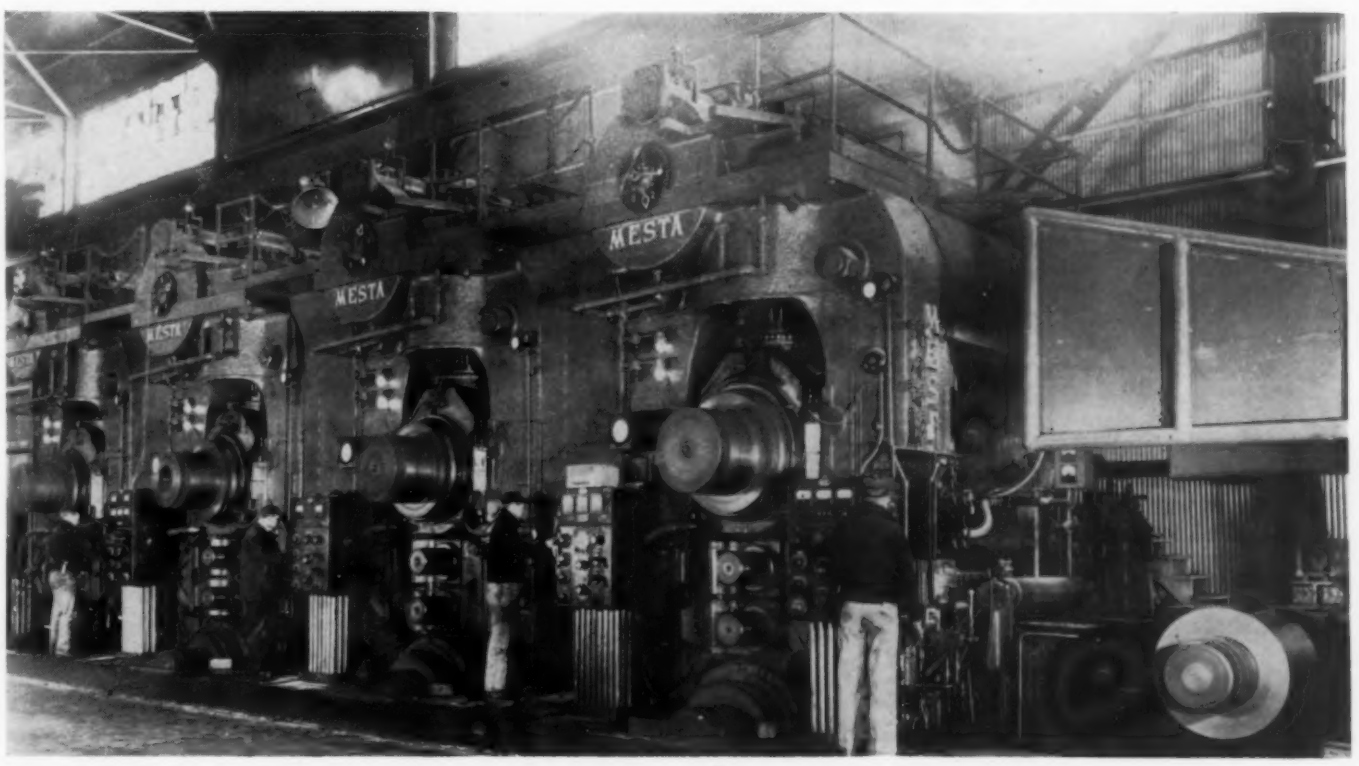
. . . . in building a mill, a solution must be found which will give adequate power for low carbon steels, but which will provide a margin to take care of stainless and other alloys which come in the future . . . .

▲ THE object of this paper is to set up motor drive ratings for a medium size tandem mill, within the parameters proven by established practice, and examine the transient factors.

In those processes in steel making where one piece of steel has work done on it at more than one point simultaneously, the control involves imparting characteristics to different masses in motion so as to keep the required relation between them at all times during operation. Since in the tandem mill, steel can only be rolled under tension, the control must regulate the rotating masses of the mill, drive motors and the steel itself to maintain the desired tension.

Consideration then of the coordinated electrical drive

Figure 1 — This is a typical four-stand tandem mill which is used as an example in the design computations outlined in this paper.



includes not only steady state outputs at given speeds, but the transient factors as well, the latter becomes increasingly important with required rapid changes in speed in acceleration and deceleration. In the transient factors, the inertia of masses and electrical inductances both result in time delay in response to change. While, with present day regulators, it is possible to obtain the same response in system components of different time constants, as is necessarily done in some systems, best results are obtained when these transient factors are matched.

STEADY STATE POWER REQUIREMENTS

Product — In setting up steady state power requirements it may be well to represent, in an elementary way, the mechanical job to be done, and relationship of components.

With the size of mill selected, let us select a speed of 4000 fpm for delivery of low carbon steel entering at 0.076 in. thick by 40 in. wide and finishing at 0.012 in. by 40 in., as an average product. The mechanical relationships are represented in Figure 2, where the changes in strip speed due to reduction in each stand

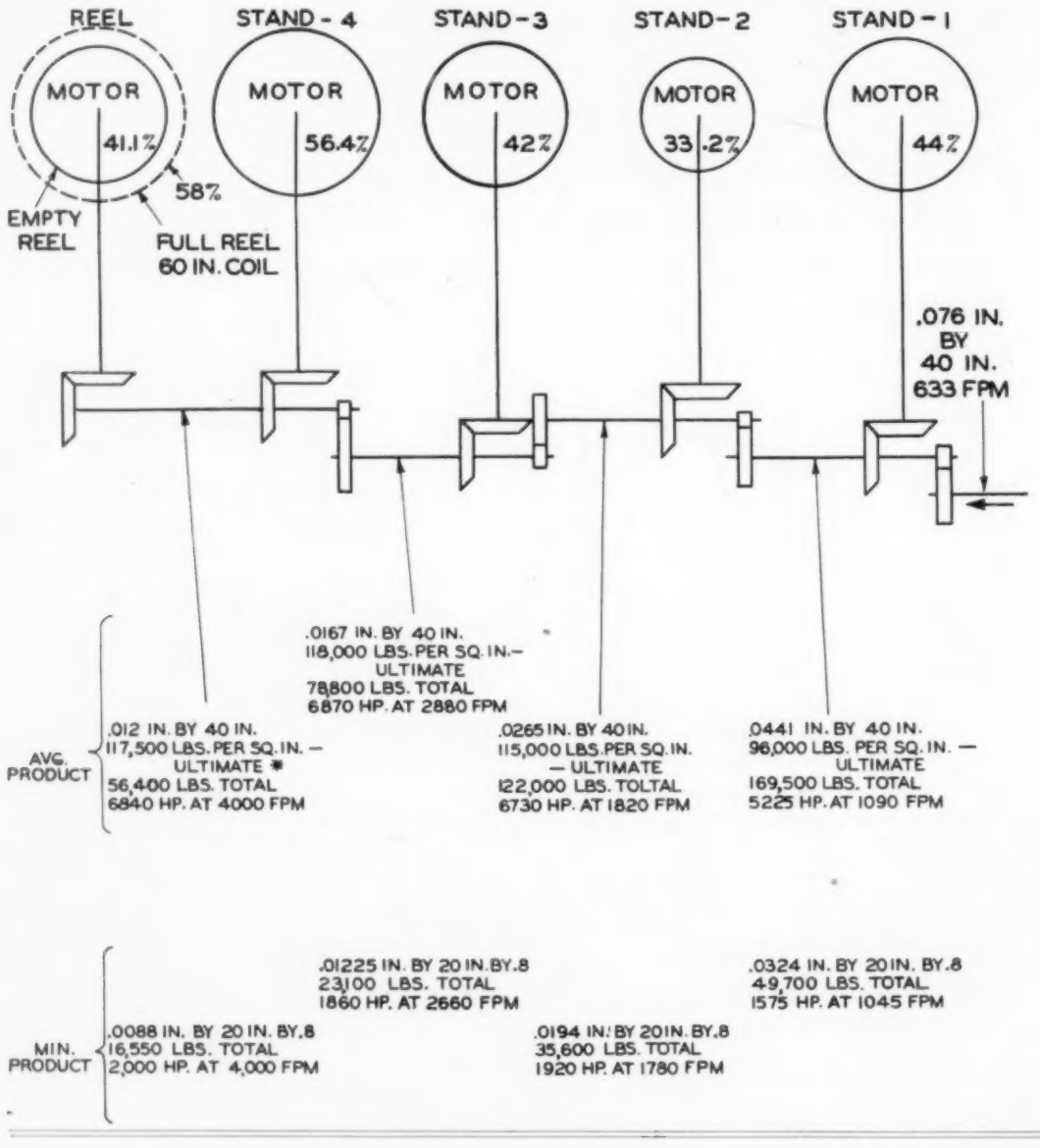

REEL
STAND - 4
STAND - 3
STAND - 2
STAND - 1
MOTOR
MOTOR
MOTOR
MOTOR
MOTOR
41.1%
56.4%
42%
33.2%
44%
58%
EMPTY REEL
FULL REEL 60 IN. COIL
.076 IN. BY 40 IN. 633 FPM
.0167 IN. BY 40 IN. 118,000 LBS. PER SQ. IN. — ULTIMATE 78,800 LBS. TOTAL 6870 HP. AT 2880 FPM
AVG. PRODUCT
.012 IN. BY 40 IN. 117,500 LBS. PER SQ. IN. — ULTIMATE * 56,400 LBS. TOTAL 6840 HP. AT 4000 FPM
.0265 IN. BY 40 IN. 115,000 LBS. PER SQ. IN. — ULTIMATE 122,000 LBS. TOLTAL 6730 HP. AT 1820 FPM
.0441 IN. BY 40 IN. 96,000 LBS. PER SQ. IN. — ULTIMATE 169,500 LBS. TOTAL 5225 HP. AT 1090 FPM
.01225 IN. BY 20 IN. BY .8 23,100 LBS. TOTAL 1860 HP. AT 2660 FPM
.0324 IN. BY 20 IN. BY .8 49,700 LBS. TOTAL 1575 HP. AT 1045 FPM
MIN. PRODUCT
.0088 IN. BY 20 IN. BY .8 16,550 LBS. TOTAL 2,000 HP. AT 4,000 FPM
.0194 IN. BY 20 IN. BY .8 35,600 LBS. TOTAL 1920 HP. AT 1780 FPM

Figure 2 — The mechanical relationships between the various components of the mill are illustrated in this schematic drawing.

It is impractical to fully match the transient factors because to do so involves:

a. Product.
b. Parameters of design.
c. Economics.
d. Setting of the mill itself.

Among these variables the best compromise must be reached.

We have selected a medium mill 54-in. wide with four stands for average product, finishing at 0.012 in. thick for this study. Such a mill may be used for the lighter sheets or for tinplate. A typical tandem mill is shown in Figure 1.

are represented by gear ratios. All motors then are represented as connected to a common mechanical load in parallel, namely, the steel strip, illustrated as a common line shaft. The gear connecting each motor to the common shaft is figurative only, and has 1:1 ratio so as not to effect the inertia constants.

The mechanical force holding the drive motors together is tabulated in the lower part of Figure 2, the top row of figures taken for the average product and the lower set of figures taken for the minimum thickness to be rolled. In the latter set of figures, the factor of 0.8 is taken because strip breakage is occasioned by cracks in the edges of the strip, and the strip is con-

sidered weaker at the vertical centerline of the rolls, termed the pass line, where it is under heavy pressure. The figures for hp are the values required to break the strip in exerting tension, at the specified speeds.

While present theory holds that in cold reducing, the strip must be stretched above its elastic limit, most students agree that this occurs only in the area of the "bite" of the rolls. This "bite" is taken to be the area within angle θ in Figure 3a. It was at one time thought that between stands in a 3, 4 or 5-stand mill, there was enough strength in the steel to hold the driving motors together with relatively insensitive control, as compared to present standards. Successful operation was dependent on inherent machine characteristics.

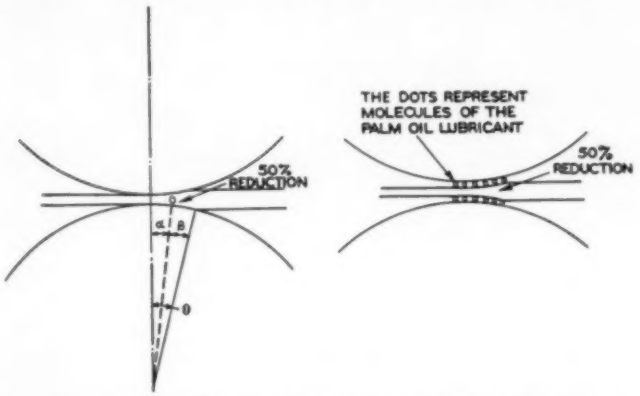


Figure 3 — The steel in the bite area is stretched above the elastic limit.

The process development, however, was made possible by virtue of better control than was previously available.

Theoretical calculations of rolling power for reduction of steel are made in terms of hp per cu in. of steel moved. To this must be added friction of bearings, work expended in deformation of rolls, etc., which is quite difficult to evaluate. Therefore, measurements from operating practices are used. The values in Figure 4 were taken from a large number of mills in operation and include all these factors. We select average values midway between the maximum and minimum for this study.

Since the work is practically independent of speed, we are enabled to calculate the hp required at the speed selected of 4000 fpm. These values are given in Figure 5.

In passing it may be interesting to note that in Figure 5, the strip is passing from left to right, as viewed from the position of the operators, whereas in Figure 2, the direction is opposite. The former is termed a right hand mill and the latter a left hand mill. Often such mills are set side by side and each operated from a common aisle. This terminology fixes the order of arrangement of equipment.

Since in the rolling operation, the work is done by a combination of roll pressure on the steel and tension between stands as well as that exerted by the delivery reel, the second factor to be taken from experience is that of the horsepower used to exert tension. The values given in line 11b, Figure 5 have proven applicable to this size and type of mill. The net horsepower required for the motors of each stand and the reel, line 13, Figure 5, then is found from suitably adding and subtracting these tension horsepower values from the net rolling horsepower given in line 9.

Parameters of design — Now that for a given application, the steady state horsepower values required to do the rolling job on an average product have been arrived at, the next step is to select motor size and ratings. This falls to the machine designer and application engineer and is of concern to the maintenance engineer.

The demand for higher and higher production rates, calling for progressively higher speeds of mills and the drive motors, puts on designers the need for the so-called "stove pipe" motor. This motor is one having minimum diameter and resulting long core length for a given rating in order to reduce the radius of gyration to a minimum.

The years of experience in operating practice since conversion from steam to electrical main drive, and particularly with the growth in the use of high speed mills since this conversion, have dictated certain design limitations. Obviously then, considerations of both horsepower ratings and WK^2 values in this study must be made in conformity with design parameters which have been proven in practice.

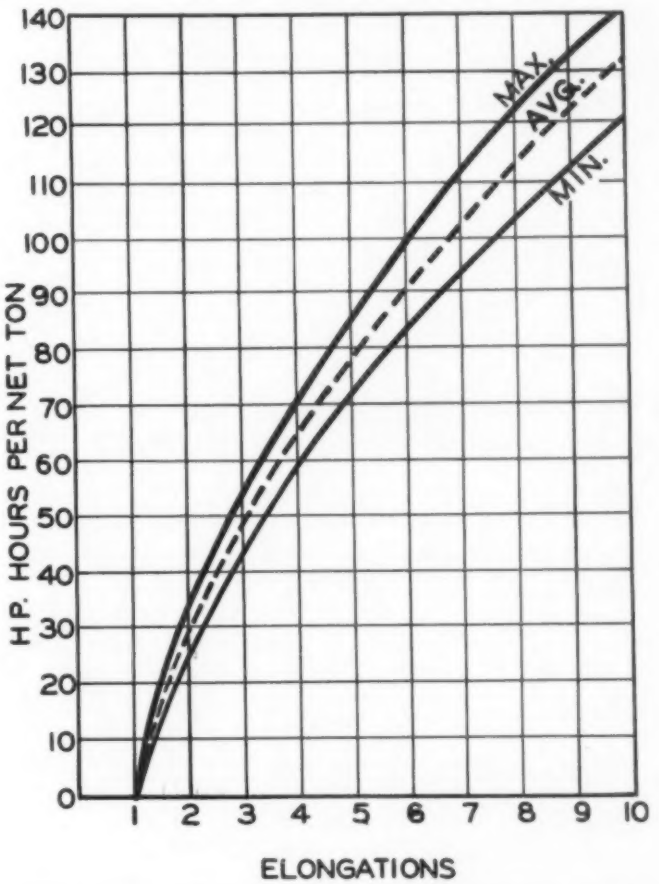


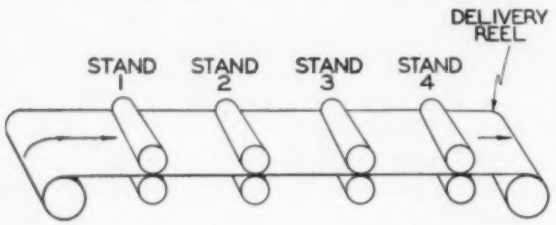
Figure 4 — Sketch gives power requirements for cold rolling on tandem and reversing mills.

There are seven limitations which if exceeded affect machine life and maintenance.

A balanced design of d-c motors for main roll and reel drives (in the opinion of the authors) falls within limitations (a) through (g) given in the Appendix.

Choice of ratings — Since the drive requires substantially constant torque for any chosen rolling schedule, the required horsepower increases directly with speed.

In selecting motor ratings to suit the horsepower requirements of Figure 5, we begin with Stand No. 4 because it has the highest strip speed and, therefore, resulting stored energies and accelerating currents have more effect on operation as a general rule, than on the other stands and the reel.



1	PASS NUMBER		1		2		3		4	
2	STRIP THICKNESS	.076		.0441		.0265		.0167		.012
3	STRIP CROSS SECTION	3.04		1.765		1.060		.667		.480
4	PER CENT REDUCTION		42		40		37		28.0	
5	TOTAL ELONGATION		1.72		2.87		4.55		6.33	
6	STRIP FPM	633		1090		1820		2880		4000
7	NET TONS per HR	195		195		195		195		195
8	HP. HR. PER TON									
	a. TOTAL FROM FIG. 4		22.0		44.5		72.0		94.0	
	b. PER PASS		22.0		22.5		27.5		22.0	
9	NET ROLLING HP.		4300		4390		5360		4300	
10	ACCELERATING HP.									
	a. MILL WK^2 AT MOTOR									
	b. GEAR RATIO									
	c. MOTOR WK^2									
	TOTAL WK^2									
11	STRIP TENSION									
	a. PER SQ. INCH			20000		30000		40000		9000
	b. TOTAL			35300		31800		26700		4330
12	TENSION HP.			1170		1750		2330		525
13	NET MOTOR HP.		3130		3810		4780		6105	525

POWER CALCULATIONS

ROLLING 40 IN. WIDE BY .076 IN. THK. TO 40 IN. WIDE BY .012 IN. THK.

$$\text{NET TONS PER HOUR} = \frac{(\text{AREA IN SQ. INCHES}) \times \text{FPM}}{9.82}$$

NET ROLLING HP. = NET TONS PER HR. x HP. HR. PER TON PER PASS

$$\text{TENSION HP.} = \frac{\text{TOTAL TENSION} \times \text{STRIP FPM}}{33{,}000}$$

Figure 5 — Table gives sample power calculations for rolling 40-in. x 0.076 in. strip down to 0.012 in. strip.

Table I shows hp, for drive motors for No. 4 stand at a strip speed of 4000 fpm. Column 5 of this table shows the number of motor armatures possible within the limitations (a) to (g) given above, and the hp rating of each necessary to supply the total needed horsepower.

However, definite determination of motor armature arrangement cannot be made without balancing the effects of WK^2 and economics.

Transient factors — The WK^2 values used in this paper are for machines designed within limitations (a) to (g). A general formula which gives WK^2 values within ± 10 per cent accuracy is:

$$WK^2 = (0.0044 + 0.00033L)\ D^{3.75} \qquad \text{(Eq 7)}$$

WK^2 values and the resulting stored energies at various maximum mill speeds determine three important factors in successful cold mill operation:

a. Accelerating currents.

b. Rate of acceleration.

c. Facility of tension control.

Steel mill main drive machines are normally rated 200 per cent load for one minute and 175 per cent load for frequently applied loads. The limit of overload is normally determined by commutation. Accelerating currents up to 75 per cent of full load rating represent good practice.

Since at any given rate of acceleration, WK^2 values and stored energies at top speed determine accelerating currents, the maximum rate of acceleration is determined by the intermittent overload rating of the machines. Accelerating currents at the minimum accelerating time must fall within the intermittent machine ratings and are determined by minimum WK^2 values consistent with a balanced design.

Mill data:

Work rolls are 20½-in. diam × 54 in. long.

WK^2 of mill and mechanical drive parts are taken as 42,000 lb ft.^{2}

Motor speed range by field weakening is 2-1/3 to 1 (max).

Stand No. 4

hp = 4670 for 4000 fpm

or hp = 1.167 × fpm

accelerating time = 9.12 sec to 4000 fpm (9.12 sec accelerating time is chosen from average practice)

or (accelerating time) ta = 0.00228 × fpm

$$\text{rpm} = \frac{\text{fpm} \times 12}{20.5 \times \pi} = 0.1863 \times \text{fpm}$$

Accelerating current in per cent of full load motor current is based on continuous rated torque. Therefore hp used is for max speed.

$$\%\text{I accelerating} = \frac{100 \times WK^2 \times \text{rpm}^2}{1.613 \times 10^6 \times \text{ta} \times \text{hp}}$$

(derived from force = mass × acceleration)

$$\text{I accelerating} = \frac{100}{1.613 \times 10^6} \times \frac{WK^2\ (0.1863 \times \text{fpm})^2}{0.00228 \times \text{fpm} \times 1.167 \times \text{fpm}} = 0.00081\ WK^2 \qquad \text{(Eq 8)}$$

Column 9 of Table I shows accelerating current in percent of full load amperes for the four possible armature combinations.

Economic comparison — The ratings at 4000 fpm are made up to show a comparison of various motor armature combinations. The size and number of motor armatures available were determined from design limitations (a) to (g) above. In line 3 for example, if the required 4670 hp were built into one armature, its diameter would be 95 in. which causes peripheral speed to exceed limitation (d) above at the required 320/740 rpm. In line 4, with two armatures, we also exceed limitation (d) in respect to peripheral speed, and besides the WK^2 is sufficiently high to cause an accelerating current of 101.8 per cent.

With three motor armatures as given in line 5, a nominal accelerating current of 74.8 per cent is obtained.

The accelerating current may be reduced further by going to four armatures where it becomes only 56.3 per

TABLE I

1	2	3	4	5	6	7	8	9	10	11
Strip fpm (max)	WK^2 mill	Per cent full load current acceleration mill parts	Motor hp	No. armatures and hp per armature	Motor WK^2	Acceleration time (ta)	Per cent full load current acceleration for motor	Total per cent full load current acceleration	Roll rpm	Temperature rise, C
4000	42,000	34	4670	1 / 4670	220,000	9.12	173.0	207.0	320/745	40*
4000	42,000	34	4670	2 / 2333	83,600	9.12	67.8	101.8	320/745	40**
4000	42,000	34	4670	3 / 1557	50,400	9.12	40.8	74.8	320/745	40
4000	42,000	34	4670	4 / 1167	32,500	9.12	26.3	56.3	320/745	40

*At this hp, the diameter of armature would exceed limitation d above (diameter = 95 in.).
**At this hp, two armatures give too high WK^2 and peripheral speed.

cent, but with added cost of an additional armature, space requirement and complication in control equipment.

A cost comparison of these four combinations is given in Table II.

TABLE II

Hp	Armatures	Cost, per cent
4670	1	86
4670	2	94
4670	3	100
4670	4	103

These values are for motor alone and do not include change in cost of control.

Thus we see that for the single armature and double armature motors, allowable peripheral speeds make them impractical to build, while due to WK^2, their accelerating currents exceed the generally accepted frequently-applied overload ratings. The three-armature combination gives accelerating current within nominal overload capacity, but based on steady load requirements for stand 4, as given in Figure 5, the transient plus steady state requirements is beyond the rating of the machine. Therefore, the four armature combination is selected for stand 4 as shown in Table III.

It should be noted that the steady state load requirement for stand 4 is 131 per cent of the nominal 40 C rating selected. However, these motors are usually built with class B insulation, and so provide a 20 per cent increase in steady state horsepower capacity over the name plate rating.

The connections of generator and motor armatures for Table I are shown in Figure 6. A two-armature motor is connected as Figure 6a, a three-armature motor as in Figure 6b, a four-armature combination as in Figure 6c.

Delivery reel — A generally accepted value of tension in the strip being coiled as it leaves the last stand is 8000 psi. For the heaviest strip 0.0359 in. thick the power is:

$$\frac{8000 \times 0.0359 \times 48 \times 4000}{33{,}000} = 1672 \text{ hp}$$

For the lightest strip to be rolled, which is 0.0088 in. thick, the power requirement at a delivery speed of 4000 fpm and a 20-in. wide strip is:

$$\frac{8000 \times 0.0088 \times 20 \text{ in.} \times 4000}{33{,}000} = 170 \text{ hp}$$

Let us select a motor rating of 1000 hp to meet average conditions. With this horsepower, a reduction in wind-up tension or accelerating rate may be necessary on the heaviest strip to keep from exceeding the maximum frequently-applied load that can be commutated during acceleration. However, with the reel motor selected in Table III, the ratio of accelerating current to work load current is low.

TABLE III

Pass No.	Hp	Per cent acceleration, amp for 9.1 sec	Roll rpm	No. armatures
Delivery reel	1000	41.1 (empty)	255/766	1
4	4670	56.4	320/745	4
3	4670	42.0	250/590	4
2	4000	33.2	195/385	2
1	3000	44.0	120/304	1

Mill data: Reel — 20-in. diam × 54 in. long
WK^2 — 2500 lb ft^2
Reel buildup — 20 in./60 in.
WK^2 of coil itself which is 48 in. wide, with OD of 60 in. and ID of 20 in. is 118,000 lb ft^2
hp = 1000 for 4000 fpm or hp = 0.25 × fpm
Accelerating time or ta = 9.12 sec for 4000 fpm
or ta = 0.00228 × fpm

$$\text{rpm} = \frac{\text{fpm} \times 12}{\pi \times \text{coil diam}} = \frac{3.825 \times \text{fpm}}{\text{coil diam (in.)}}$$

Accelerating current in per cent of full load motor current:

Per cent I accelerating

$$= \frac{WK^2 \times (3.825)^2 \times \left(\frac{\text{fpm}}{\text{coil diam in in.}}\right)^2 \times 100}{(0.00228 \times \text{fpm} \times 0.25 \times \text{fpm}) \quad 1.613 \times 10^6}$$

$$= 1.59 \times \frac{WK^2 \text{ (motor + coil)}}{(\text{coil diam})^2} \qquad \text{(Eq 9)}$$

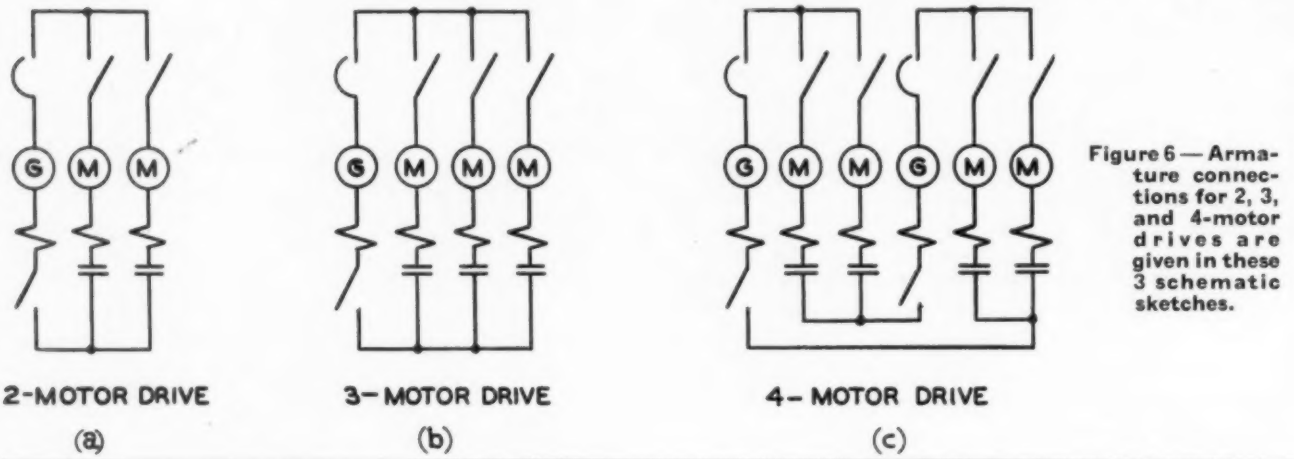


Figure 6 — Armature connections for 2, 3, and 4-motor drives are given in these 3 schematic sketches.

In Figure 7 the per cent full load current required by the reel at various coil diameters are given for accelerating to 4000 fpm.

The minimum current occurs at the condition when the coil diameter (32 in.) is such that the WK^2 and stored energy of the coil is equal to that of the motor and reel parts.

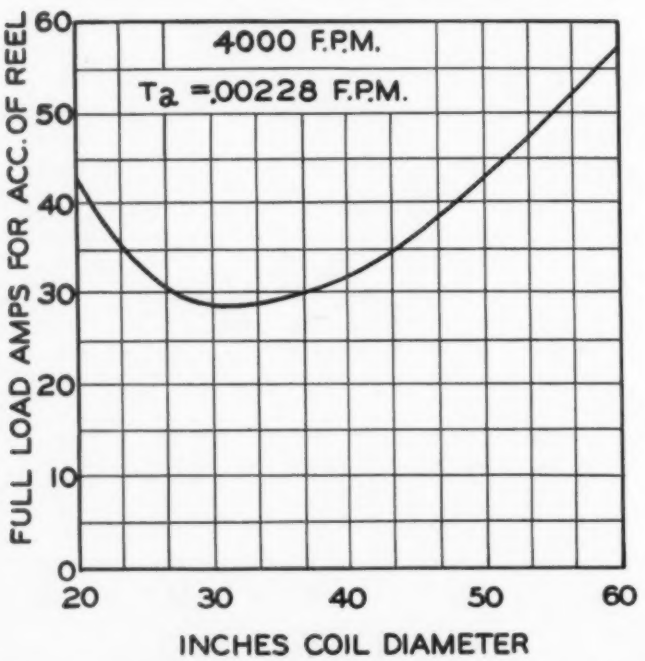


Figure 7—Curve gives per cent of full load current required by the reel for various coil diameters when accelerating to 4000 fpm.

In Table III, ratings are given for all stands and the reel at 4000 fpm.

Mill settings — All of the discussion so far has been based on reductions as given in Figure 5, line 4, for an average product. However, different products require different total reductions between the entry and delivery sides of the mill. The adjustments to fit the mill schedules require different "mill set ups." For example, the product may enter at a thickness of 0.076 in. and finish at 0.024 in. thick. This requires different motor speed adjustments.

In Figure 8 is shown the so-called "cone" for a four-stand tandem mill. Curve 1 shows the highest motor speeds required within the motor field range for rolling. Curve 2 shows the lowest speeds for each stand, obtainable at fixed rated generator voltage, by motor field control. This curve can be lowered as required by supplying individual generators for each motor, with modern control equipment.

Further, it may be required to roll material entering at greater thickness or special alloys which require heavier torque. In these cases the field strength is increased on the motors of all stands to increase the torque per ampere to keep within the overload ratings. This, of course, reduces the mill delivery speed correspondingly.

Effectiveness of control — The effectiveness in controlling an electro-mechanical system, such as a cold reducing mill is dependent on a number of factors.

Here our scope includes only the factors of inertia.

In order to gain a perception of the factor resulting from inertia and the job required of the control equipment thereby, it is best to reduce it to representation by numbers. A graphic representation of the flywheel effect of mill and motor in terms of per cent full load accelerating current is shown in the form of circles representing each stand in Figure 2.

Prior to the development of modern control systems, it was thought necessary to maintain WK^2 values of combined mill and motor equal on all stands.[2*] Actually, the stored energy of the system at full speed is a larger factor in the effectiveness of control, since WK^2 is only one factor in stored energy. The energy value to be added or subtracted for speed change varies directly with WK^2, but as the second power of the speed (see Eq 8). Consequently, high speed mills require more accurate control and faster response than low speed mills.

In usual calculations, used for comparative purposes, a measure of the stored energy is given for top speed,

*Numbers refer to Bibliography at end of paper.

as in Table III, in terms of accelerating current in per cent of full load current. It is realized that matching stored energy at top speed is not correct for actual operation, since top speeds on all motors is seldom obtained simultaneously in rolling. This may be observed, as previously mentioned, from Figure 8. From the point of view of control, it is to be noted that the highest motor accelerating current to top speed, which is 56.4 per cent, Table III for stand 4 is less than twice the lowest of 33.2 per cent for stand No. 2 for top speed.

The mechanical tie between motors, through the strip, is represented graphically by the line shaft in Figure 2, and at the top of Figure 5. From the standpoint of controlling the motors, there is little resiliency to this tie, but a definite limit to it, relative to available motor torque.

The mechanical tie through the strip serves as a torque equalizer between motors, but is unilateral. For example, during acceleration, if the control supplies the correct load torque plus the correct per cent accelerating current to overcome inertia (i.e. supply stored energy at the proper rate) and less than the proper amount is supplied to stand 3, an extra amount of tension develops in the strip sufficient to accelerate No. 3 motor at the rate corresponding to the acceleration of No. 4 motor. If power supplied to No. 4 motor is correspondingly less than that supplied to No. 3, the latter will accelerate faster and the strip will loop.

The inertia constants of the system then are an important factor in effectiveness of control. This factor is dependent on two components:

1. The first of these is the ratio of accelerating current to steady state tension load current.

$$A/T = \frac{\text{Accelerating current (per cent full load)}}{\text{Tension current (per cent full load)}}$$

$$= \frac{\text{Accelerating hp}}{\text{Tension hp (rolling)}} \qquad \text{(Eq 10)}$$

This factor applies during acceleration and deceleration. From Figures 2 and 5, and Table III. Stand 4 —

Average product

$$A/T = \frac{4670 \times 0.564}{2330 \text{ (Figure 5)}} = \frac{2630}{2330} = 113 \text{ per cent}$$

Minimum product

$$A/T = \frac{2630}{792} = 331 \text{ per cent}$$

Stand 3 —

Average product

$$A/T = \frac{1960}{1750} = 112 \text{ per cent}$$

Minimum product

$$A/T = \frac{1960}{630} = 311 \text{ per cent}$$

From these data, when rolling the lightest material, the control must, at the beginning of acceleration, apply quickly and accurately 331 per cent of the motor current and torque in stand motor No. 4 that is exerted in tension between stands under steady state rolling conditions, once the mill is up to speed. It must quickly and accurately remove this amount of current and torque at the end of acceleration. More important, it must subtract this amount, quickly and accurately, without appreciable overswing, at the beginning of deceleration, otherwise tension peaks will be transmitted through the strip or it will become slack as the case may be.

Obviously, the greater the WK^2 and top mill speed, the more critical the accuracy of control becomes.

If, for example, stand No. 4 were over-motored, and the WK^2 were greater or speed greater so as to double the accelerating current, the control would have to accurately apply and remove 6.62 times the tension torque on acceleration for the minimum product. Any appreciable "overshoot" would be serious. Equivalent conditions would

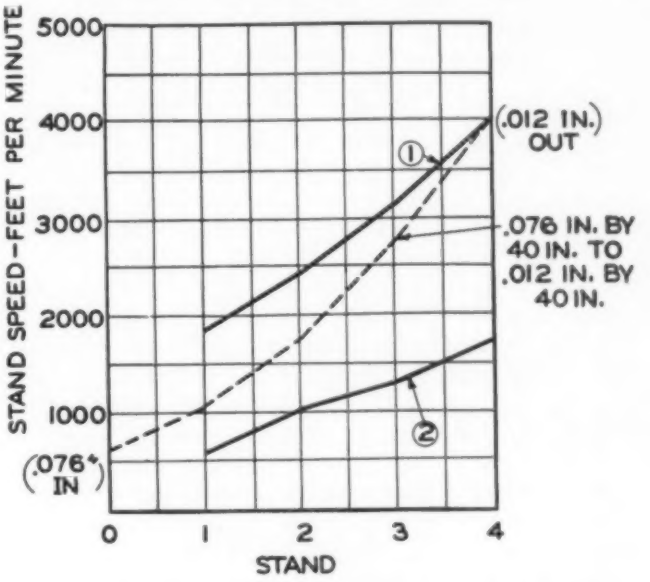


Figure 8 — Speed cone for four-stand tandem mill.

obtain for rolling a strip of one half the minimum cross section with the apparatus specified in Figures 2 and 5.

Fortunately, it is not required to keep the same tension at low speeds as at high speed. Some increase in tension at low speeds, helps get the steel "on gage" quickly in accelerating, and to hold gage to low speeds in decelerating.

2. The second component is the ratio of rolling tension to ultimate strength of the strip.

$$B/T = \frac{\text{Tension hp (ultimate strength)}}{\text{Tension hp (rolling)}} \qquad \text{(Eq 11)}$$

A considerable portion of the torque delivered to stand No. 4, for example, by its motor goes into work done on the strip by the rolls. Therefore, tension torque and roll work torque must be measured and separated to obtain this ratio. This factor is important both during speed change and steady state speed.

From the standpoint of control, the roll work load current is unimportant, since it is a fixed quantity. Any excess current put into the motor

by control equipment will result in increase in tension, since the roll work remains constant for a given screwdown setting.

Normally the combined inertia constants of mill and motor are expressed in full load motor rating as given in Tables I and III. This is necessary to select a motor size that will accelerate the mill without exceeding the short time rating.

The controllability of the mill, however, requires the expression of these constants in terms of the rolling tension load and strength of the lightest strip to be rolled, since the strip is the mechanical tie between motors in parallel.

From Eq (10) and Eq (11), the transient ratio A/T and breaking ratio B/T are given in Table IV, for the lightest strip 0.0088 in. × 20 in. reduced from 0.056 in. thick at 4000 fpm, when operating with normal tension between stands.

This acceleration ratio A/T is independent of the amount of current and hp absorbed by the rolls, but depends on the operators actual setting of tension value. This value probably changes somewhat with different operators. It is to be referred to values given in line 12, Figure 5 (for lightest strip).

As illustration, suppose that for the heaviest strip 75 per cent of the motor rated current and hp is absorbed in roll work, 25 per cent in tension, and that 75 per cent is required for acceleration. The steady state motor load then is 100 per cent. It must be increased to 175 per cent during acceleration and decreased to 25 per cent during deceleration.

Thus the transient load current (and hp at top speed) which the control handles is three times the steady state tension current. If the regulator has a sensitivity of 5 per cent then (0.05 × 175 per cent = 8.75 per cent) the variation in tension may be $\frac{8.75}{25} = 35$ per cent.

Table IV covers the lightest strip to be rolled and the column A/T shows that the accelerating current for the reel, for example, is 2.14 times the tension.

TABLE IV

Stand No.	A/T	B/T	$\frac{B-T}{A}$
Delivery reel*	2.14	10.4	4.4
4†	3.31	2.35	0.406
3†	3.11	3.05	0.66
2†	3.24	3.83	0.88
1	....	....	....

*With empty reel.
†With tension (ultimate strength) values from Figure 2.
Where: A = hp for acceleration at top speed.
T = hp for tension at top speed.
B = hp for ultimate strength at top speed.

The breaking ratio factor B/T, Eq 11, gives the value beyond which the motor current may not be increased, even momentarily, without breaking the strip, in terms of tension current during steady rolling. Thus the hp on stand No. 4 may increase to 2.35 times the tension hp before breaking the strip.

$$\frac{\text{Breaking hp-Tension hp}}{\text{Accelerating hp}} = \frac{B-T}{A} \qquad \text{(Eq 12)}$$

It is of interest to put the hp that will break the strip in terms of accelerating hp, since the latter is the transient quantity added and subtracted during acceleration and deceleration respectively.

For example, on stand No. 4 (column $\frac{B-T}{A}$ Table IV) the hp required to reach ultimate strength of the strip is 0.406 or 40.6 per cent. Therefore, it represents 0.406 × 56.4 = 22.9 per cent of full load motor current.

Thus, on acceleration where it is required that the control add 56.4 per cent field motor current, an over swing of an additional 22.9 per cent (79.3 per cent total) can be withstood before the strip ultimate strength is reached.

The figures in Table IV are for a well balanced mill and will be used for comparison in mills not so well balanced, to be set up in a later article.

With the WK^2 values and mill speeds set up here, the mill is controllable without ultra accurate and sensitive control, since on the most critical motor, stand No. 4, a momentary over swing in current of 22.9 per cent of full load value is required to break the lightest strip rolled.

Other d-c machine characteristics are included in the transient factors affecting the effectiveness of control. Some of these are IR drop, motor and generator regulation, armature and field inductances. It is not possible in the space available, to discuss them here. IR drop compensation for acceleration lag has been proposed[4] for judging the matching of accelerating characteristic of a group of motors.

SUMMARY

a. Many variables are encountered in the drive of mills for cold rolling steel. It is impractical to include all of the pertinent ones in a single paper.
b. A medium size tandem mill is studied.
c. The limitations of practical motor design are given.
d. Several possible motor ratings are established.
e. Choice of ratings is made from consideration of economics and inertia factors.
f. Practical physical design limitations determine the extent to which flywheel effect can be reduced.
g. The choice of the number of motor armatures is the most practical means of arriving at a flywheel effect which will not impose too great a duty on the equipment.
h. The inertia constants have been studied and the duty imposed on control has been considered. These factors have been coordinated so that the motors selected provide a balanced drive based on present mill practice.
i. These inertia constants indicate that for a given motor rating, the job required of the control becomes more exacting as the cross section of the strip decreases.
j. They also show that for a given rolling job to be done, excess margin in capacity in motor size, as

for example to cover a wide range of products, makes the requirements of control more exacting with increase in such excess.

In building a mill, then, the steel mill engineer must find the most practical solution to the problem of availing himself of adequate hp for current production in low carbon steels, and of providing a margin that will serve for stainless and other alloys which future production requirements may some day necessitate.

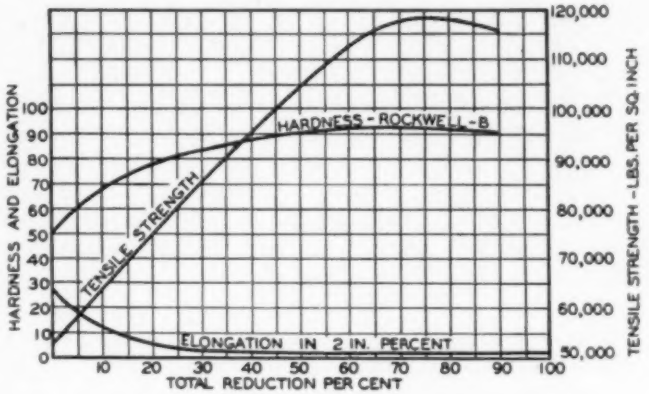


Figure 9 — Changes in physical properties with reduction are given by these curves.

If margin in maximum hp is desired, consideration must be given to providing reasonable accelerating ratio factor and breaking ratio factor for the lightest strips to be rolled, so that the mill may be controlled stably when rolling these strips.

BIBLIOGRAPHY

1. "*The Modern Strip Mill*," by T. J. Ess, published by Association of Iron and Steel Engineers, 1941.

2. "*Acceleration of Tandem Cold Strip Mills*," by T. R. Rhea and M. J. Leding, 1939 Proceedings of Association of Iron and Steel Engineers, pp 270-280.

3. "*Electric Equipment for Cold Strip Reduction Mills*," by W. E. Miller, AIEE Trans. 1949.

4. "*Acceleration Characteristics of Tandem Cold Reduction Mills*," by W. R. Harris and R. W. Moore, 1951 Proceedings of Association of Iron and Steel Engineers, p 431.

APPENDIX

Design limitations of 40 C rise, compensated, d-c motors.

a. Volts per commutator bar.
The tendency of the machine to flashover is determined by the average volts per commutator bar. The maximum safe value is approximately 18 volts per bar.

$$\frac{p \times E}{S} = 18$$

or

$$S = \frac{p \times E}{18} \qquad \text{(Eq 1)}$$

These values are for steady state conditions.

b. Ampere conductors and armature diameter.
The ampere conductors per inch of armature circumference are limited by heating (radiation plus convection) to 1100 for smaller motors, and 1300 for the larger motors.

$$\text{Turns per coil} \times \frac{2 \times S \times I}{\pi \times p \times D} = 1100 \text{ to } 1300$$

or

$$S = \frac{\pi \times D \times p \times 1100}{2 \times I \times \text{turns/coil}} \qquad \text{(Eq 2)}$$

c. Watts output per inch of armature diameter.
This is obtained by combining equations 1 and 2

$$\frac{p \times E}{18} = \frac{\pi \times D \times \text{paths} \times 1100}{2 \times I \times \text{turns (coil)}}$$

$$\frac{E \times I}{D} = \frac{18 \times \pi \times 1100 \times \text{paths}}{2 \times p \times \text{turns/coil}} \qquad \text{(Eq 3)}$$

kw = 31.1 per in. or 42 hp per in. of armature diameter for 1100 ampere conductor loading for a one turn lap winding.
This value is independent of core length.

d. Armature surface velocity is limited to approximately 10,000 fpm due to mechanical problems.
$v = 10{,}000$ fpm (Eq 4)

e. Output factor obtained from combining the above factors:

$$OF = \frac{w}{\text{rpm} \times D^2 \times L} = 0.065 \text{ to } 0.075 \qquad \text{(Eq 5)}$$

This factor as well as limitation (a) determines the heat rise of the machine.

f. Ratio of core length to diameter.
$L = 1.4 \times D$ (normal limit) (Eq 6)
This value is chosen because of factors of ventilation, balance and shaft strength, and apply to motors which must be designed near the limits of (a), (b), (c), (d) and (e).

g. Reactance volts.
It is necessary to maintain the proper reactance volts across brushes at top motor speed at probably no more than 25 to 30 volts at rated current, to obtain successful commutation.

p = number of poles
E = volts
S = number of commutator bars
I = amperes (line)
D = armature diameter in inches
fpm = feet per minute
OF = output factor
w = watts
rpm = revolutions per minute
L = length of core in inches

DISCUSSION

PRESENTED BY

W. R. HARRIS, Manager, Metal Working Section, Industry Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

W. E. MILLER, Manager, Steel Mill Section, Industrial Engineering Dept., General Electric Co., Schenectady, N. Y.

T. B. MONTGOMERY, Engineer-in-Charge, Control Design, Allis-Chalmers Mfg. Co., Milwaukee, Wisc.

W. R. Harris: Messrs. Sellers and Montgomery have presented a good picture of the inertia problem on accelerating and decelerating mill drives. There are, however, two points which we believe merit further consideration. First, as was stated, WK^2 alone is often a misleading consideration in determining the acceleration performance of tandem cold reduction mills. The WK^2 merely sets the upper limits of loads which will be experienced on the various motors during normal speed changes and on emergency stops. It tells practically nothing about how the motors will stay together during acceleration periods. To get this picture you must use "acceleration lag" which is the per cent accelerating current multiplied by the per cent IR drop, and which is the same thing as the mechanical time constant of the motor and its connected system. The proper balance of these characteristics is discussed in the paper "Acceleration Characteristics of Tandem Cold Reduction Mills" by Harris and Moore which appears in the 1951 Transactions of the Association of Iron and Steel Engineers.

Second, in any discussion of tensions between stands in a tandem cold reduction mill, the overgage which occurs at low speed must be considered. The metal actually gets 15 to 40 per cent heavier as the mill is decelerated from operating speed to threading speed. Therefore in one case where 40 per cent leeway in accelerating current was calculated by the authors, the increase in gage alone might wipe out all of the leeway. The increase in gage at threading speed is one of the most troublesome factors to contend with in designing a drive for a tandem cold reduction mill. Any study of accelerating tensions must take this factor into consideration.

W. E. Miller: This paper emphasizes a side of the problem that sometimes tends to be overlooked, i.e. the "controllability" of the mill. Mr. Montgomery more or less said that he was going to stick to tandem mills, but I think that we both agree that the problem is important on other types of mills, particularly temper mills. For instance, on the payoff reel, we must not forget that we must stop the equipment as well as hold back tension, and that we need a peak rating at least that will permit a stop in a reasonable length of time. Thus, the payoff drag generator rating may be set more by overall system "controllability," as Mr. Montgomery calls it, rather than by back tension requirements.

Other problems of "controllability" arise when dealing with wind-up reels of dual purpose tandem mills, i.e., combination sheet and tin plate mills. In addition, many times the tin plate product being rolled has edge cracks with resultant stress concentrations in which case the tension must be accurately controlled during transients if strip breakage is to be avoided. In such cases, particular care must be exercised in the selection of the motor, as well as the regulating system, to be sure that the overall equipment is controllable under all specified operating conditions.

T. B. Montgomery: The discussion brings out one thing, there is more to learn about the art of rolling. Maybe other people do, but we do not feel we know all about it. There are so many variables in a tandem mill, and in any mill, that no doubt a lot of good results can be obtained as we study further. The factors studied involve many variables, I could mention some in addition to those named. In any problem one tries to solve, the more variables thrown into it, the more terms there are in the formula, and the more variables, the more laborious becomes the solution, so we have to resort to analog computers.

In the point that Mr. Harris brought out, I do not think he takes issue with us. We are limited here entirely to the WK^2 values or the stored energy values, leaving out the other factors. As Mr. Harris gave in his former paper, this lag, or motor lag, includes the electrical time constants of the motors themselves. The forty per cent we use is based entirely on the stored energy, not on any other variables that are introduced into the problem as a result of what happens in the motors themselves, such as armature resistance and lag of fields in response.

Another factor is that I do not think we have as yet the complete yardstick we mentioned. In tandem mills the motors are pretty well balanced, whereas if we consider a single stand reversing mill, for example, we do not have as good balance. We found ourselves one time trying to control a mill that had a 1700-hp reel motor with a 3.1 gear ratio. We were rolling tinplate and trying to control that motor to a 100-hp output, so you can imagine what that problem is compared to the motors analyzed here. It is a pretty good job, if you can do it. I bring this up in order to give an example of controllability projecting a hard control problem.

Other studies, foreign to the steel industry, have contributed to the general experience with the type of drives considered. With the variables in motors, especially time lags in motors, where several operate mechanically in parallel in one operation, such as a tandem mill, the electrical as well as the inertia constants have to be added together. We have found in such jobs as wind tunnels, for example, where accurate results are a necessity, that the only way to get the required results by design, is to set it up on analog computers. We did that on one job, and came out on test within about four and a half per cent of calculated values. So calculations such as the ones presented here certainly do not give us all of the answers, but rather give us one phase, and I hope we can pick up from there and carry on to a little more complete perspective.

W. H. BAILEY, British Iron & Steel Research Association, London, England

NEW BREAKER BLOCK DESIGNED TO LIMIT ROLL LOADS

. . . . the device described is newly designed, built, and thoroughly tested, although no actual mill applications have been installed up to the present time . . . .

▲ ECONOMIC operation of rolling mills, like that of other large modern production units, often depends upon driving them as near the limit as safety will allow. Heavy loading without increased breakdown calls for: (a) accurate measurement of the load, and (2) a device which will prevent the safe maximum from being exceeded. Ideally, a rolling mill should be fitted with devices for these purposes, as axiomatically as a boiler is equipped with a pressure gage and safety valve. Effective roll force meters have been designed and used in the United Kingdom for the first mentioned measurement for some time past(1)*, following unsuccessful attempts to measure roll force by using extensometers on the mill housings(2), and by various other methods.

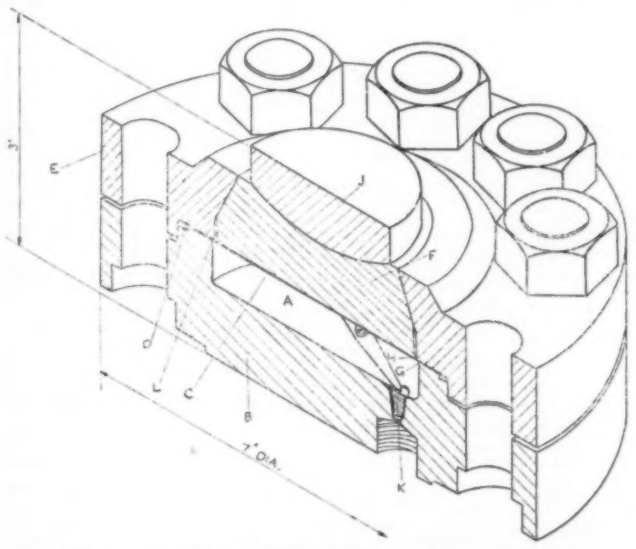


Figure 1 — Isometric section through breaker block.

Up to now the second device mentioned, the safety device has (if used) generally been a cast iron breaker block between the chock and the screws, this block fracturing when sufficient overload occurs, allowing the chock to rise. A major disadvantage of this device is the inconsistency of the mechanical properties of cast iron. Even when sound castings of identical dimensions and from the same ladle are used, breakers may vary from the mean by as much as 10 per cent. For different casts of the same nominal composition, the variation may be as much as plus or minus 20 per cent. Consequently, the performance of cast iron breaker blocks must be forecast on the basis of the properties at the top of the range, and breakages will actually occur when the mill is under considerably less load.

The British Iron and Steel Research Association decided to tackle this problem at their rolling mill laboratories in Sheffield, England. They have now produced a pressure-filled breaking piece, which acts consistently to within 2 per cent of the stated load; more than that, it is so designed that the breaking load can be adjusted readily to suit the condition of the rolls in use. (U.S.A. patent No. 2,612,798.) The description that follows is of an actual breaking block that has been tested in a 50-ton compression testing machine.

Figure 1 is an isometric view. Its construction and operation are as follows:

The cavity A in the base B is closed by the soft copper diaphragm C, about 0.005 in. thick. A fluid-tight joint between the diaphragm and the base is made by compression of a copper ring D by a retaining ring E. Resting upon the copper diaphragm is a punch F, upward movement of which is prevented by the retaining ring secured to the base by a ring of bolts. The inwardly projecting lip at the mouth of the cavity, and the outwardly projecting lip of the punch have hardened cutting edges G and H, respectively. A spherically seated pad J receives the thrust of the mill screw and the base rests upon the chock. The base, punch and retaining ring are made of oil-hardened steel, having the approximate composition C, 0.6 per cent; Mn, 0.3 per cent; Si, 1.0 per cent; Cr, 1.0 per cent. Before inserting in the mill, the pressure in the cavity is raised by pumping in gas with or without liquid through a non-return valve K until it is such as will support the difference between the load at which the breaker is intended to operate, and the load required to shear the

*Numbers refer to Bibliography at end of article.

Figure 2 — Component parts of breaking piece.

diaphragm, any excess of the fluid thrust over the roll force being carried by the retaining ring. It will be seen that if the thrust from the screw should exceed the fluid thrust by more than the shearing force of the diaphragm, shearing will take place. This will enable the fluid to pass into the clearance space L and through the space which will have opened between the punch and the retaining ring as the former descends relative to the latter. The chock will then be free to rise and relieve the force on the roll neck. The diaphragm is not intended to contribute to the load-carrying capacity, but only to prevent the escape of fluid until operation of the breaker takes place.

The sealing ring is made by bending $\frac{1}{8}$-in. diam soft copper wire around the spigot of the base and cutting it so that the ends butt squarely when it is tapped into the recess in the retaining ring. After assembly, the retaining ring is pressed down on to the base with a force of about 50 tons in a compression-testing machine or suitable hydraulic press, which reduces the vertical

Figure 3 — Breaker block is shown assembled.

diameter of the wire from 0.125 in. to 0.093 in., and it is the resulting lateral spread which provides the sealing pressure.

The diameter of the punch over the cutting edge is $3\frac{3}{8}$ in., giving a face area of 10.6 sq in. and the travel of the punch is about $\frac{9}{16}$ in. The overall diam is 7 in. and the depth $3\frac{1}{4}$ in. Figures 2 and 3 show the breaking piece dismantled and assembled respectively.

The non-return valve at present in use consists of a small brass plug, tapered at an included angle of 10 degrees, seating in a polythene sleeve in a hole reamed to the same taper in the base. This valve has proved entirely fluid-tight, but a new sleeve is required after two or three chargings to maximum pressure.

It is essential that there be some gas present in the cavity to allow the diaphragm to move down while being sheared. The air initially present is insufficient (at 5000 psi it would be compressed, in the present

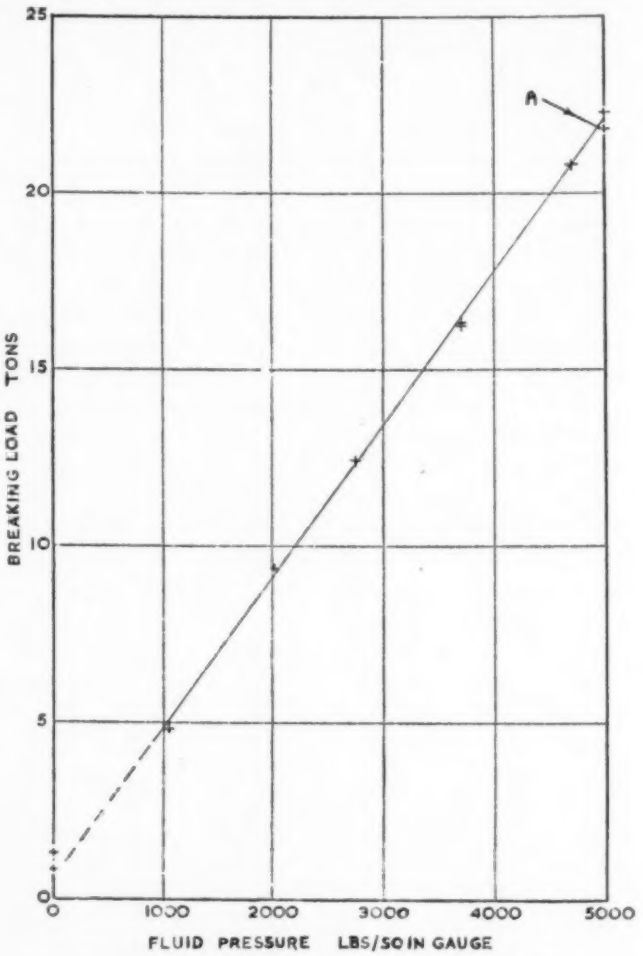


Figure 4 — Performance of breaker block in testing machine is shown by curve.

example, to a layer only about 0.002 in. thick) and charging is commenced, therefore, by connecting the breaker to a full or nearly full gas bottle, which provides an initial pressure of the order of 1500 to 2000 psi. In the tests, nitrogen has been used for convenience.

Connection is then transferred from the nitrogen bottle to a high-pressure oil pump, fitted with means of indicating the pressure, such as a Bourden gage or a ground and lapped plunger loaded with dead weights, and oil is injected to displace gas and raise the pressure to the figure required. Oil rather than additional gas is

used because of the greater ease with which it can be pumped.

Results of the tests in the compression testing machine are shown in Figure 4. It will be seen that the maximum departure of a load from the mean line is 1.6 per cent, and that there was no significant loss of pressure when standing charged for a week (Point A). In these tests the temperature at breaking was the same as at charging; each degree difference between them would cause about 0.3 per cent change in the breaking load.

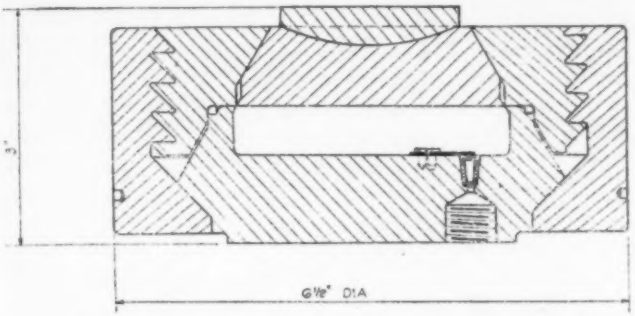


Figure 5 — An alternative design may be used with a screwed collar, instead of bolts and nuts.

Figure 5 shows an alternative design in which a screwed collar is used to replace the bolts and nuts, and it is estimated that it would be capable of a safe load capacity of 50 tons for a diam and height of 6½ in. and 3 in. respectively, as against 25 tons for the design tested, in which the diam was 7 in. and the height 3¼ in.

The field of application of an accurate and adjustable breaker block such as this may be large. Besides the manufacture of steel and non-ferrous metals, that of paper and rubber offer obvious possibilities, and there must be many more fields of technology where accurate limitation of pressure is a factor affecting economic production.

BIBLIOGRAPHY

1. "*Loadmeter for Industrial Mills*," by Sims, Place and Morley, Engineering (London), January 25 and February 1, 1952.

2. "*The Control and Recording of Rolling Mill Pressures*," by M. Stone. 1936 Proceedings of Association of Iron and Steel Engineers, p 319.

Advance Orders Now Being Taken for

Tube Mill Practice

A collection of articles from the IRON AND STEEL ENGINEER on various phases of tube making.

Practical information on layout and operation of facilities for seamless, butt and electric weld pipe, a field in which little information has been published . . . 23 articles by 20 authoritative writers . . . invaluable for engineers, operators, trainees and students.

8-¼ x 11-¼ in.,. . . . . 196 pages, illustrated, clothbound

Price: To AISE Members . . . $2.00
To Others $4.00

ASSOCIATION OF IRON AND STEEL ENGINEERS
1010 Empire Building
Pittsburgh (22), Pa.

A NEW HIGH TEMPERATURE ALLOY

By M. N. ORNITZ
Works Manager
National Alloy Steel Div.
Blaw-Knox Co.
Blawnox, Pa.

and

R. H. ENGLISH
Chief Metallurgist
National Alloy Steel Div.
Blaw-Knox Co.
Blawnox, Pa.

. . . . the alloy described permits services up to 2200 F, which is an increase of about 200 F above previously available common alloys . . . .

▲THE limitations imposed upon many high temperature processes by the oxidation and creep rates of the heretofore available commercial heat resistant alloys have long been apparent. The need for increasing the temperatures of these processes becomes more critical with today's increased operating costs. Over a period of many years, this need was emphasized by requests for an alloy which could be used for temperatures in excess of 2000 F, with sufficient strength to have practical engineering application at 2200 F, and sufficient oxidation resistance to give a satisfactory operating life at this temperature. While these inquiries have predominantly been received from furnace manufacturers, numerous requests have also been received from operating metallurgists, fuel engineers, ceramic engineers, as well as those in the power boiler field; all of whom have recognized the potential value of such an alloy. The alloys heretofore available have been inadequate. Their lack of high temperature properties has imposed extremely undesirable limitations on engineering design. It was desired by these engineers and designers to improve their processes both from a quality and economical point of view. Increasing the rate of heating by the use of higher heat heads would greatly contribute to an increase in furnace capacity and efficiency, if such an alloy were available.

Recognizing the need for a new high temperature alloy, a major research project was undertaken for the development of a heat resistant alloy which would have the necessary properties, namely resistance to oxidation and ability to maintain its shape under load. There are many, perhaps, who do not realize the scope of such a project. Heat resistant alloys have been developed mostly by a process of brute force and awkardness in conjunction with the available scientific information. This involved the testing of many additions of variable percentages to a given base material. The results do not always follow the theoretical prediction; and, in addition, it takes not days, but months, or even years for an alloy to be evaluated.

As a result of this research, an alloy was developed and subjected to extensive tests both in the laboratory and in the field. This alloy has been designated NA22H and is covered by United States patent number 2,540,-107. NA22H makes possible practical engineering applications at temperatures up to 2200 F; an increase of 200 F over previous practical design limitations for alloys. Its properties will be described later.

In recent years, extensive study and considerable publicity has been given to the expensive super-alloys. These super-alloys, while excellent for strength at temperatures up to 1900 F, have little merit in creep strength above this temperature. Their properties at the lower temperatures are obtained primarily through the precipitation of complex compounds which form in a range of approximately 1200-1900 F. (1).* When this temperature is exceeded, the precipitate goes into solution and/or coalesces, markedly weakening these alloys. Furthermore, it has been demonstrated that many of the Ni-Cr-Fe super-alloys with their special alloy additions such as Mo and V are inferior to the straight Ni-Cr-Fe alloys in their resistance to oxidation in air at temperatures over 1475 F (2) and (3). These additions have an extremely detrimental effect by causing accelerated corrosion. It has also been shown that many of the high cobalt super-alloys with an addition such as Cb have higher oxidation rates than the high Ni-Cr-Fe alloys at temperatures of 2200 F in air (4).

There are many alloys which have high strength at elevated temperatures and very poor oxidation resistance, and conversely there are alloys which have excellent oxidation resistant properties but are extremely weak. It is natural that the experimenters be guided by the basic fundamentals involved in the process of high temperature deformation in order to develop materials for use at elevated temperatures. Early in the investigation, it became apparent that at the temperatures under consideration, namely 2000-2300 F, it was necessary to strengthen the solid solution matrix of the

*Numbers refer to Bibliography at end of article.

alloy in combination with the formation of stable complex carbides, rather than strengthening by the formation of a precipitate. It was also found that without proper chemical balance to form a tight adherent oxide scale, the additions of such elements as Mo and V and certain ranges of Cr and W resulted in a porous oxide which accelerated the oxidation of the alloy. Thus the problem was two-fold: (a) to strengthen the Ni-Cr-Fe base alloy, and (b) to develop sufficient oxidation resistance in conjunction with these strengthening elements.

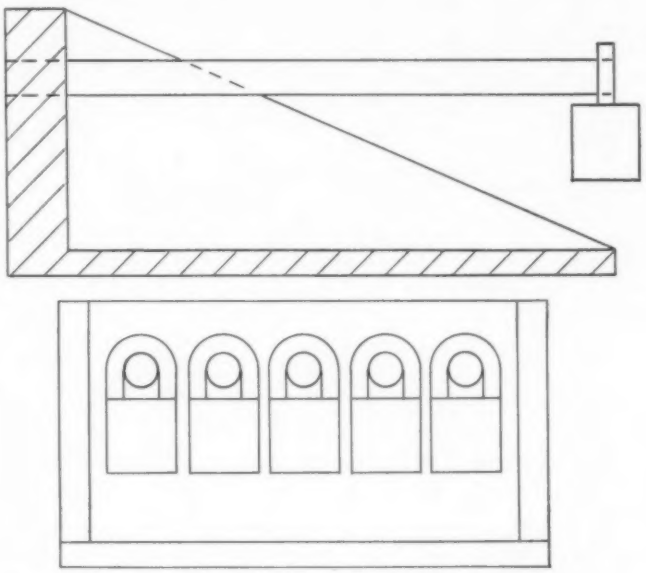


Figure 1 — Cantilever creep test fixture is set up to run tests on a number of specimens.

The large number of test samples which had to be tested in a research project of this magnitude made it imperative that a new, reproducible and inexpensive procedure be developed which would make possible the comparison of both the creep and oxidation resistance of a number of different materials simultaneously, and at temperatures up to 2300 F. This was achieved in 1942, by the development of the cantilever beam test method which will be described later.

After this new alloy, NA22H, was developed by this test procedure, its engineering properties were evaluated in the standard tensile creep and stress rupture testing equipment, and it is this data which will be presented in this paper.

EXPERIMENTAL PROCEDURE AND EQUIPMENT

It is not the purpose of this paper to describe established testing procedures, consequently the description is limited to the new techniques which were developed for and during this research project. The most serious problems involved were in the development of the cantilever beam creep test and the building of a high temperature furnace for tensile creep and stress rupture testing which would enable the evaluation of alloys at temperatures up to 2300 F.

The test bars for use in the cantilever beam creep test (5) are machined to ½ in. diam by approximately 11 in. long. One end is fastened securely in an angle shaped heat resistant fixture as a simple cantilevered beam. Heat resistant weights are added to the free end of the bar to vary the stress as desired. This arrangement is shown in Figure 1. The test holder and specimens are placed in a gas-fired muffle furnace which has full proportioning control capable of holding the temperature to plus or minus 2 F up to a maximum of 2400 F. After the test bars reach the desired temperature, readings are taken periodically of the deflection of the free end of the bar. A traveling microscope capable of measuring to 0.0001 in. is used for this purpose. Temperatures are recorded at the region of maximum stress by means of platinum-rhodium thermocouples. In Figure 2, considering the length of the test bar as X, the measured deformation of the free end as Y, then Y/X is the tangent of the angle. Since for small angles, the tangent of an angle is equal to the angle in radians, this angle was considered as unit deformation in bending due to the maximum stress applied to the cantilevered test bar. Obviously the maximum plastic deformation in the bar takes place near the fixed end. This deformation in turn is magnified by the length of the bar to give the reading Y. Thus, it is readily apparent that very small amounts of plastic deformation can be easily and accurately measured. When the angle in radians is plotted against time, a creep curve which is characteristic of that found in the standard type of tensile creep testing is obtained. However, fracture does not occur due to the fact that the test bar will eventually rest upon the holder if the stress is high enough for the temperature involved. There is good reproducibility of the results obtained in the stage of steady creep. In fact, cantilever bending creep testing has recently been shown to have advantages over tensile testing (6).

Elevated temperature tensile creep and stress rupture test bars were machined to 0.505 x 2¼ in. gage length and were in accordance with ASTM E22. The temperature during the test was held within the limits imposed by this specification. The control thermo-

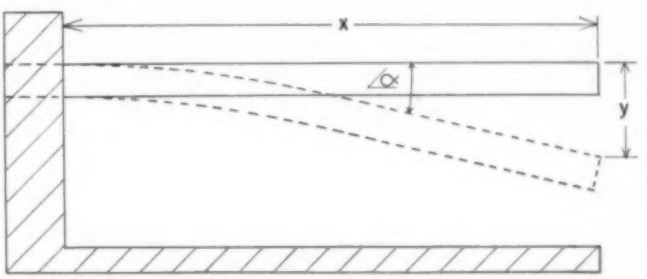


Figure 2 — The angular deformation is used as a measure of strain in the cantilever creep test.

couple was located in the same radius as the heating elements to give fast response and to minimize the fluctuations in the test bar. Conventional resistance wound furnaces were used up to 2000 F. Silicon carbide heating elements were used above this temperature. The construction of these furnaces is shown in Figure 3. The outer heat resistant alloy tube and the inner alundum tube serve to equalize temperature differentials. Six silicon carbide elements were wired as two sets in parallel, each set consisting of three elements in series. A seven-kva continuously tapped auto transformer was used to vary the power input. The grips and alloy tube were made of NA22H. The minimum time for temperature equilibrium was established at 24 hr.

Thermal fatigue tests were made to determine the susceptibility of NA22H to heat shock. The furnace used for this test was essentially the same as that shown in Figure 3, except four elements were used in each set and the two sets were wired in parallel. The specimen usd was a radiographically sound disc 3½ in. in diam and ½ in. thick. This disc and the refractory bottom of the furnace were mounted on an alloy bar which once each hour was automatically lowered to a position below the furnace where the disc was quenched with either a jet of water or air, as the conditions required. The number of cycles required to crack the disc was used to evaluate alloys in regard to their resistance to thermal shock.

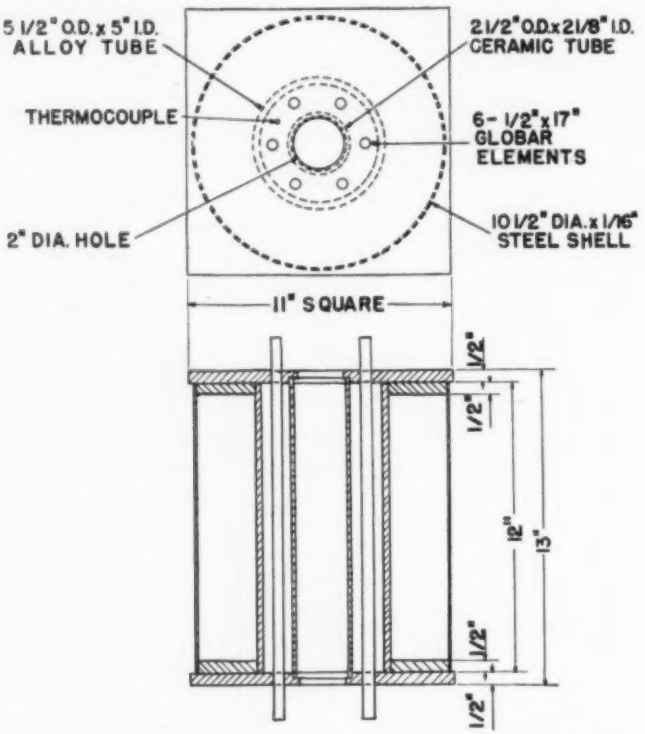


Figure 3 — Schematic diagram shows construction of test furnace.

The thermal expansion specimens used were radiographically sound bars 1 in. diam by 3 in. long. These bars were heated in a cylindrical furnace. The expansion was measured by two parallel quartz tubes in conjunction with a unique system of levers and compensating links. This eliminated errors that might arise from shifting and expansion of the work platform and temperature differentials of the quartz tubes. The expansion of the bar is actually multiplied 112 times. The instrument was equipped for the simultaneous recording of length and temperature.

ENGINEERING PROPERTIES

The room temperature mechanical properties of NA22H is normally of little importance since there is no correlation between room temperature strength and that at elevated temperatures. However, due to the occasional short time loading conditions that may occur in service and certain restricted welding conditions, the short time tensile properties at elevated temperatures may be desirable. These are listed in Table I along with the room temperature properties.

TABLE I

Short Time Mechanical Properties of NA22H

Temperature, F	Tensile strength, psi	Reduction of area, per cent	Elongation, per cent
Room	64,500	2.7	3.5
1200	54,500	15.2	13.0
1300	53,125	19.5	18.5
1400	47,250	23.4	23.5
1500	38,350	25.8	24.5
1600	29,500	37.9	26.5
1700	22,675	42.5	38.0
1800	18,000	48.0	32.0
1900	14,175	47.5	33.5
2000	9,700	47.8	40.0
2100	7,225	....	50.0
2200	5,175	....	50.0
2300	3,300	....	52.5

For comparative purposes, Table II lists the "as cast" mechanical properties of several of the commercial heat resistant alloys at room temperature, 1600 F and 1800 F (7) (8) (9) (10) (11) 12).

TABLE II

As Cast Mechanical Properties of Various Heat Resistant Alloys

Material	Room temperature		
	Tensile strength, psi	Reduction of area, per cent	Elongation, per cent
NA22H	64,500	2.7	3.5
35 Ni-15 Cr (HT)	68,000	10.0	10.0
25 Cr-20 Ni (HK)	71,750	....	16.0
25 Cr-12 Ni (HH)	75,000	25.0	20.0
		1600 F	
NA22H	29,500	37.9	26.5
35 Ni-15 Cr (HT)	18,500	36.0	28.0
25 Cr-20 Ni (HK)	20,000	25.1	11.0
25 Cr-12 Ni (HH)	18,000	28.8	23.5
		1800 F	
NA22H	18,000	48.0	32.0
35 Ni-15 Cr (HT)	11,300	26.0	27.0
25 Cr-20 Ni (HK)	10,600	17.4	24.0
25 Cr-12 Ni (HH)	10,000	50.3	45.0

It can be seen from these data that the short time tensile strength of NA22H is superior to that of the standard commercial heat resistant alloys at temperatures of 1600 F and 1800 F. Although data has been presented for NA22H up to 2300 F, similar values of the

TABLE III

Free Bend Test

Temperature, F	Degrees Bend
75	36
500	54
700	43
800	76
900	81
1000	70
1100	93
1200	96

TABLE IV

Creep and Stress Rupture Test Data

Heat	Temperature, F	Stress, psi	Duration, hr	Minimum rate, per cent per hr	Elongation, per cent	Reduction in area, per cent
212992	1800	2315	1642 no fracture	0.00010	0.6	.....
216997	1800	2500	1580 no fracture	0.00044	4.4	.....
1	1800	3005	2189	0.00118	11.0	8.5
2	1800	4000	317.5	0.0080	11.0	23.5
312151	1800	4210	557	0.0149	16.0	20.8
211943	1800	4420	181	0.082	25.0	26.8
211943	1800	5500	70	0.36	37.5	43.4
212992	1900	1745	2457 no fracture	0.00057	1.8	.....
422684	1900	2000	1300	0.00338	10.0	18.8
216428	1900	2000	570 no fracture	0.0030	2.0	.....
422684	1900	2500	900	0.0054	10.0	20.6
422684	1900	3000	308	0.0356	18.0	24.0
316496	1900	3250	202	0.0512	28.0	30.0
216294	2000	1200	1600 no fracture	0.00071	7.0	.....
2261	2000	1475	917.6 no fracture	0.0009	0.5	.....
422684	2000	1500	1000	0.0023	13.0	11.0
2263	2000	1600	776	0.0012	8.0	11.5
422684	2000	1760	518	0.0048	7.0	9.6
212992	2000	2000	696	0.0068	15.0	28.0
4	2000	2000	763	0.0085	10.5	.....
212992	2000	2500	289	0.012	15.5	20.6
5	2000	2500	139	0.041	25.0	40.0
315992	2000	3210	34.5	0.444	43.0	45.0
7	2100	500	1500 no fracture	0.0002	3.2	.....
212992	2100	700	1270	0.0024	5.5	20.5
315992	2100	800	995	0.0041	12.0	11.5
312151	2100	1000	676	0.0092	12.5	14.0
9	2100	1760	144	0.074	18.0	27.5
422684	2200	400	2156	0.0008	19.8	.....
316002	2200	500	685	0.0020	14.0	11.5
422684	2200	675	683	0.0022	22.2	5.8
39916	2200	792	214	0.034	38.0	10.3
315992	2200	1000	62	0.112	16.0	13.3
2206	2200	1465	28	0.51	13.0	29.2
39916	2200	1465	32	0.38	24.0	29.0
316002	2300	130	2100	0.0015	6.0	7.1
216997	2300	175	338	0.0022	3.4	.....
2260	2300	225	486	0.007	5.0	.....
316002	2300	300	6.7	0.08	3.0	0.4

other alloys are unavailable in the literature. The authors have not felt the need to evaluate these properties for the higher temperatures.

While the room temperature elongation and reduction of area of NA22H is not high, this has in no way been a detriment in the casting, welding and handling of this alloy. The ductility is well within necessary practical range as can be seen from the results of a 1-½-in. radius free bend tests made on ½ in. x ¼ in. x 11.6 in. test strips machined from a 4-½ in. outside diam x 4 in. inside diam centrifugally cast tube. These results are presented in Table III.

The tensile creep and stress rupture properties of NA22H were evaluated for the temperature range of 1800-2300 F in 100 degree intervals. The minimum rate, i.e., the steady state of elongation with time, was obtained from the elongation time curves. These data are presented in Table IV, and the analyses of the various heats used are given in Table V. The creep rates and rupture times for each temperature are plotted on log-log paper to facilitate the determination of the limiting stress for a creep rate of 0.001 per cent per hr and the determination of life expectancy at a given stress level. These curves are presented in Figures 4 and 5.

It can be seen there is a straight line relationship between stress and both the creep rate and the rupture time. It should be noted that no change in slope is evi-

TABLE V

Chemical Analysis of Test Heats, Per Cent

Heat	C	Mn	Si	Ni	Cr	W
212992	0.57	1.23	1.08	48.9	26.1	6.16
216997	0.60	1.43	1.46	46.8	26.4	5.14
211943	0.46	0.62	1.00	54.6	24.0	4.40
422684	0.51	1.34	1.18	45.6	25.9	5.89
216428	0.44	1.16	1.11	49.7	27.8	5.04
315992	0.45	1.37	0.99	46.3	27.6	5.38
216294	0.49	1.25	0.85	49.0	29.2	4.08
316002	0.57	1.21	1.00	48.6	26.2	4.96
2260	0.44	0.80	1.03	49.3	29.0	4.00
2206	0.59	0.93	0.89	49.9	27.1	6.40
2263	0.48	0.79	0.90	49.6	28.0	4.30
2261	0.45	0.80	0.94	49.9	28.2	4.20
312151	0.53	1.18	1.41	43.2	28.6	5.92
1	0.56	1.00	1.50	42.6	25.9	4.64
2	0.49	1.12	1.27	43.5	27.7	4.96
4	0.48	1.10	1.46	45.6	28.3	4.72
5	0.49	1.21	1.36	43.1	27.8	5.92
7	0.56	1.24	1.41	44.1	26.5	4.80
9	0.50	1.00	1.32	42.8	27.0	5.36
39916	0.44	1.26	1.22	48.7	27.1	4.32
316496	0.52	1.15	1.27	45.2	27.0	5.41

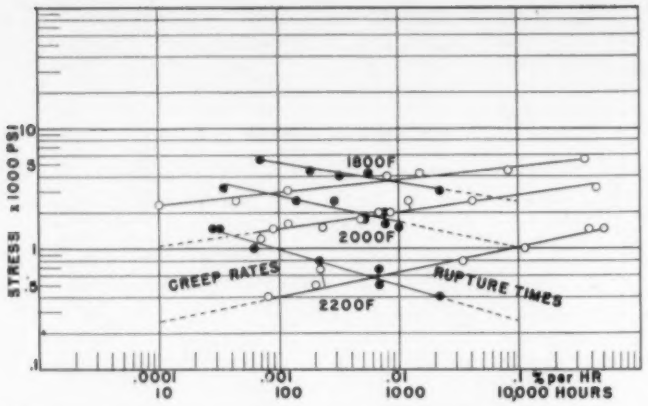


Figure 4 — Creep and stress rupture characteristics of NA-22H are shown for 1800 F, 2000 F and 2200 F.

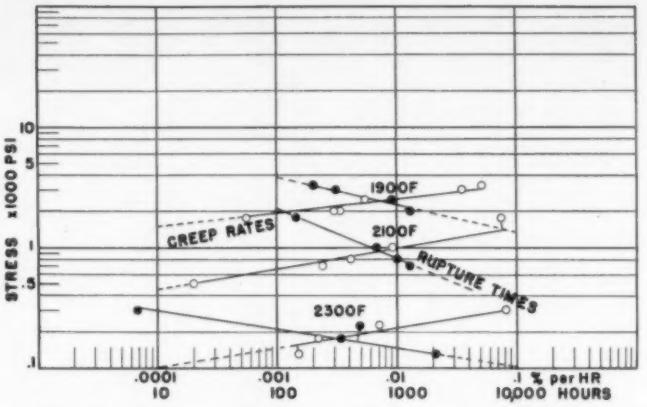


Figure 5 — Creep and stress rupture characteristics of NA-22H are shown for 1900 F, 2100 F and 2300 F.

dent in any given curve. It has been demonstrated that materials not adequately oxidation resistant and/or susceptible to intergranular oxidation do not exhibit this relationship for creep rates vs. stress. Structural changes in the alloy account for changes in the slope of the rupture curve (13).

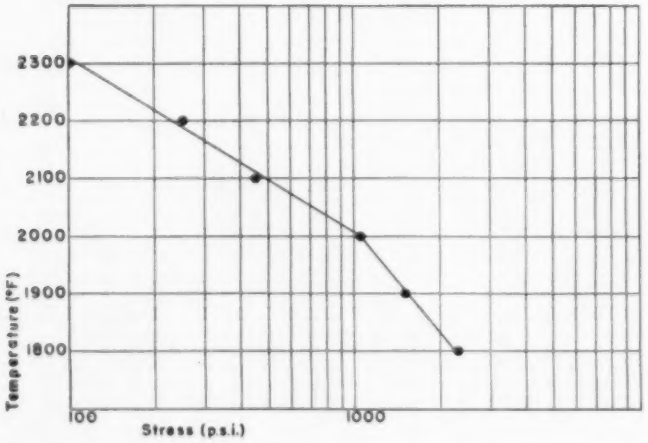
For the purpose of high temperature engineering design, the stress to produce a creep rate of 0.0001 per cent per hr (1 per cent per 10,000 hr) is used as the base value. From this stress, design values are determined dependent upon service conditions. The actual design stress will be a modification of this base value dependent upon such factors as type of loading (static, rotating, nonuniform); temperature conditions (14) (uniform, degree of cycling); thermal shock, etc. This point cannot be overemphasized. In general, the use of the stress vs rupture time plot will give an indication of the life expectancy of an alloy. However, it is not wise to extrapolate such a curve for extremely long periods of time.

TABLE VI

Stress for Minimum Creep Rate of 1 Per Cent per 10,000 Hr and Rupture Life for NA22H

Temperature, F	0.0001 Per cent elongation per hr	100-Hr rupture life	1000-Hr rupture life
1800	2300	5200	3600
1900	1500	3800	2350
2000	1050	2800	1670
2100	450	2100	820
2200	250	1000	500
2300	100	210	145

Figure 6 — Stresses for a creep rate of 0.0001 per cent per hr are given for NA-22H for temperatures from 1800 to 2200 F.



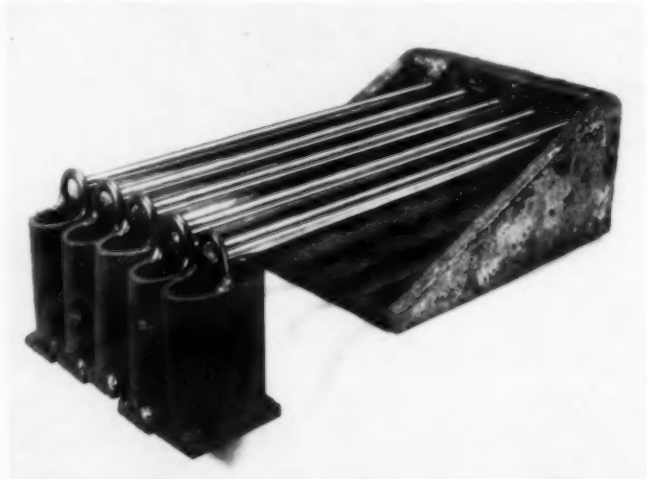
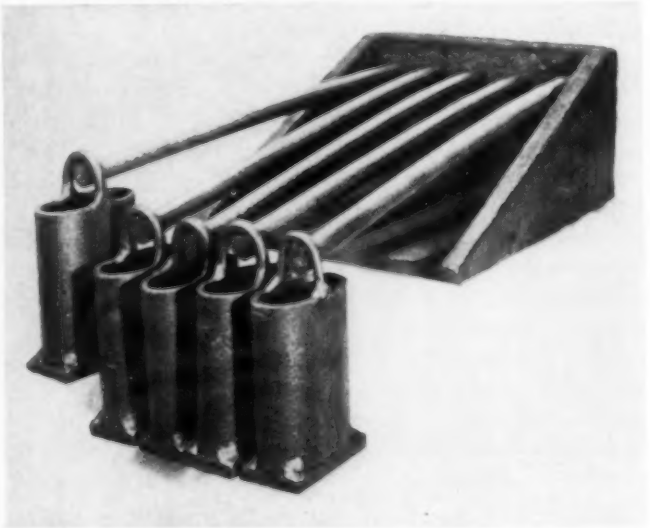


Figure 7 — Cantilever creep test has specimens loaded to give stresses of 1750 psi before test.

Table VI summarizes the stresses that will give a minimum creep rate of 0.0001 per cent per hr for the temperatures of 1800-2300 F as well as stress levels re-

Figure 8 — Illustration shows cantilever creep test after 200 hr at 2000 F at a stress of 1750 psi.



quired to give 100-hr and 1000-hr rupture life for NA22H. The limiting stress for NA22H as effected by temperature is plotted in Figure 6. Of interest is the straight line relationship of this plot. Such a condition is not characteristic of the commonly used heat resistant alloys.

Early in the experimental work, cantilever creep testing revealed that NA22H, in comparison with the commercial alloys, had much greater resistance to creep. The marked superiority of NA22H over four commercial alloys normally used for high temperature service can be illustrated by two cantilever beam tests. One test was run at 2000 F, and the other at 2200 F. Figure 7 shows a cantilever creep test loaded to produce a maximum fiber stress of 1750 psi before being subjected to 2000 F. Figure 8 shows the same test after 200 hr at this temperature. The bar on the left showing the least amount of deformation is NA22H. The other bars are respectively, from left to right, 35 Ni - 15 Cr, 25 Cr - 12 Ni, 25 Cr - 20 Ni and 65 Ni - 15 Cr. A

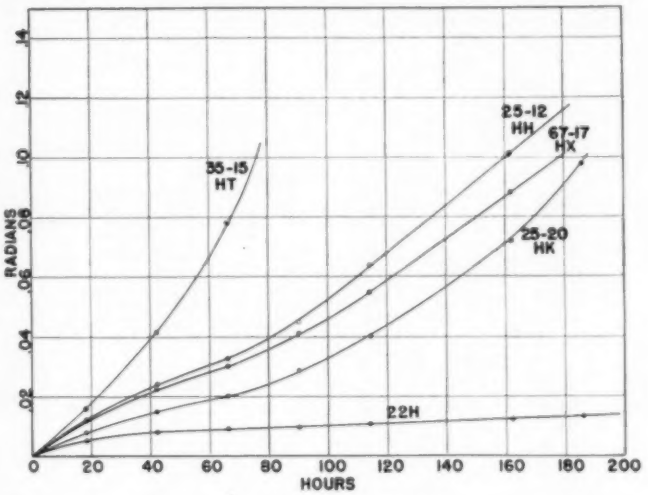


Figure 9 — Time-deformation curves for the cantilever creep test at 2000 F and 1750 psi are given for several materials.

plot of the deformation, as measured by the tangent of the angle in radians, vs time is shown in Figure 9. It will be noted that not only did the four commercial alloys have a much higher minimum rate, but that they also had a very short steady state, usually referred to as stage 2. Apparently these alloys entered very rapidly into stage 3, i.e., an increasing rate of bending. The commercial alloys had bent to the point where they touched the bottom of the furnace and the test was discontinued. It will be noted that NA22H had deformed to only a small degree under this very high load,

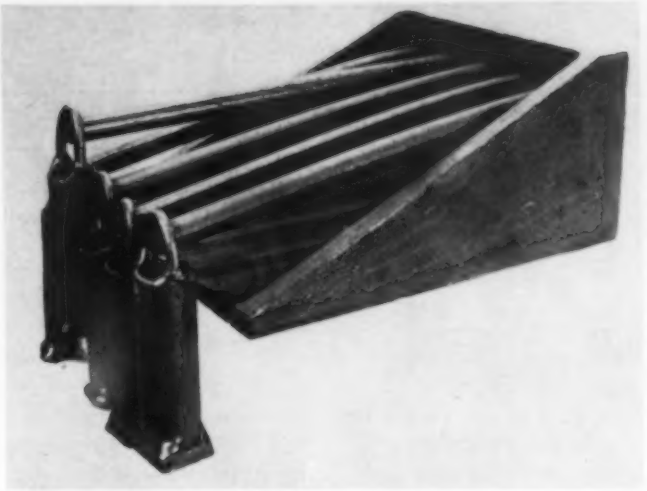


Figure 10 — Illustration shows cantilever creep test after 200 hr at 2200 F at a stress of 500 psi.

and even after 200 hr there is no apparent change in the steady state of creep of this bar. Table VII tabulates the analyses and minimum creep rates of these alloys.

Another concrete example of the superior high temperature strength of this new alloy can be shown by a

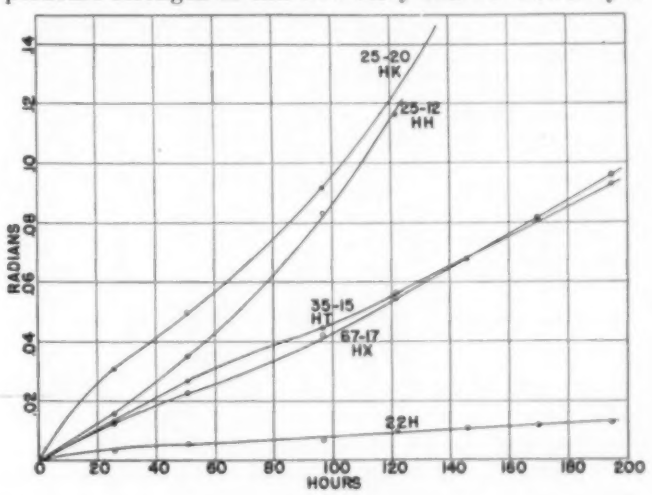


Figure 11 — Time-deformation curves at 2200 F and 500 psi as given by the cantilever creep test are given for several materials.

similar cantilever creep test run at 2200 F under 500 psi stress. Figure 10 shows this test after 200 hr. The alloys are from left to right, 25 Cr - 20 Ni, NA22H, 35 Ni - 15 Cr, 25 Cr - 12 Ni, 65 Ni - 15 Cr. To illustrate the shift in strength between several of the common commercial heat resisting alloys at 2200 F, as compared to

TABLE VII

Cantilever Creep Results — 1750 psi @ 2000 F

Alloy	Analysis						Minimum creep rate, radians per hr
	C	Cr	Ni	Mn	Si	W	
NA22H	0.44	26.3	46.0	1.36	0.99	5.28	0.0000381
35/15 HT	0.42	17.2	34.9	1.33	1.78	.....	0.000978
25/12 HH	0.37	25.8	12.8	1.35	1.36	.....	0.000367
65/15 HX	0.44	13.8	65.6	1.33	1.83	.....	0.000353
25/20 HK	0.27	24.8	18.6	1.52	1.32	.....	0.000204

TABLE VIII

Cantilever Creep Results — 2200 F @ 500 psi

Alloy	Analysis						Minimum creep rate, radians per hr
	C	Mn	Si	Ni	Cr	W	
NA22H	0.53	1.25	1.08	48.2	27.0	5.84	0.0000625
25/20 HK	0.32	.....	.....	17.2	25.8	.....	0.000765
35/15 HT	0.44	.....	1.75	35.0	17.5	.....	0.000436
25/12 HH	0.26	.....	1.27	12.0	26.4	.....	0.000769
65/15 HX	0.40	.....	0.99	64.5	15.6	.....	0.000418

2000 F, the deformation time curve for this test is presented in Figure 11. The minimum creep rates and analyses of the alloys tested are given in Table VIII. Again the superiority of NA22H over all the common high temperature alloys is dramatically illustrated in this unique type of testing. It is interesting to note that at the higher temperature of 2200 F, the two alloys 25 Cr - 12 Ni and 25 Cr - 20 Ni, are weaker than the 35 Ni - 15 Cr and 65 Ni - 15 Cr while at 2000 F, 35 Ni - 15 Cr is the weakest. This can probably be attributed to the higher solubility of the carbides at 2200 F of the Cr-Ni alloys as compared to the lower carbide solubility in the higher Ni materials.

The relation between elastic deflection in bending and elastic elongation in tension has been well established. However, the relation between plastic deformation under a bending stress and plastic elongation under tension is more complex (15). It has been shown (6) that for strains less than 1 per cent in cantilever creep, the maximum fiber stress calculated from the elastic theory, if multiplied by a factor, will produce similar deformation in tensile creep.

In order to show the agreement between data obtained by cantilever bending creep tests as compared to that obtained from the tensile creep tests, two temperatures, 2000 F and 2300 F, were selected and the results of these cantilever creep tests are given in Table IX. The minimum rate in terms of radians per hour was plotted against stress on a log-log graph and is presented in Figure 12. In this figure the solid lines are the creep rate as obtained from the tensile creep tests shown before in Figures 4 and 5, while the circles are that from the cantilever test. There is fair agreement between these two types of tests at the lower rates of creep. Scatter increased at the higher loads and temperatures. This seems to be in good agreement with published data.

OXIDATION RESISTANCE

Results of the oxidation tests under static non-cycling conditions is not always a proper means of evaluation. Under cycling temperature conditions, many normal heat resisting alloys will have a tendency for their protective oxide scale, so necessary to long alloy life, to spall or crack resulting in accelerated corrosion. Table X shows the comparison of corrosion rates in 100-hr constant temperature, 500-hr constant temperature and 500-hr cycling tests of NA22H at 2200 F.

TABLE IX

Results of Cantilever Creep Test

C	Ni	Cr	W	Temperature, F	Stress	Bending rate, radians per hr
0.50	48.0	28.0	5.0	2000	1100	0.00000254
0.50	48.0	28.0	5.0	2000	1200	0.00000353
0.50	48.0	28.0	5.0	2000	1300	0.0000053
0.50	48.0	28.0	5.0	2000	1400	0.00000765
0.50	48.0	28.0	5.0[1]	2000	1500	0.000011
0.44	49.7	24.6	4.85	2000	1500	0.000021
0.61	46.2	28.0	5.6	2000	1500	0.000038
0.44	46.0	26.3	5.28	2000	1750	0.0000381
0.50	48.0	28.0	5.0	2300	143	0.000035
0.50	48.7	28.0	5.0	2300	143	0.000027
0.50	48.7	28.0	6.0	2300	225	0.000046
0.56	49.3	27.6	5.5	2300	250	0.000162
0.57	49.1	28.5	4.96	2300	250	0.000164
0.55	49.0	25.6	5.28	2300	250	0.00025
0.50	48.0	28.0	5.0	2300	250	0.00019

Table X shows the comparison of corrosion rates in 100-hr constant temperature, 500-hr constant temperature and 500-hr cycling tests of NA22H at 2200 F.

Figure 12 — Curve shows correlation of results from the cantilever and tensile creep tests.

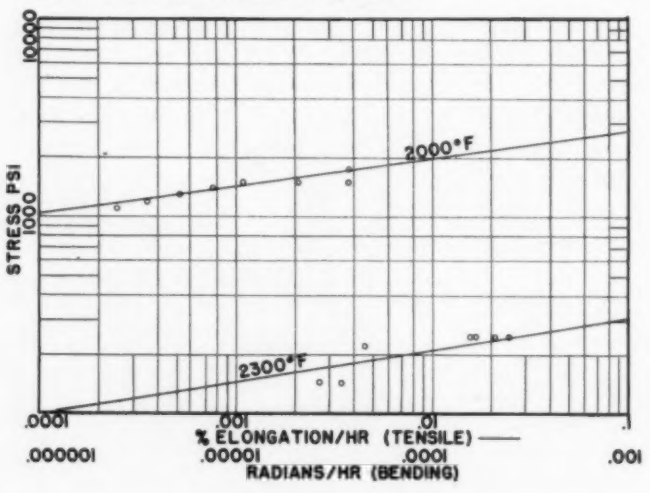


TABLE X

NA22H Oxidation Rates in Air at 2200 F

100-Hr constant temperature	500-Hr constant temperature	Cyclic (500 hr at 2200 F)
0.045 in. per yr	0.041 in. per yr	0.06 in. per yr

The 500-hr cycling test at 2200 F was obtained by heating samples 21 hr at 2200 F, cooling to 800 F and reheating to 2200 F. This cycle was repeated every 24 hours. The specimens were at 2200 F for 500 hr. The data indicates that cycling has only a slight effect upon the oxidation rate of NA22H. It further shows that the short time test provides conservative figures for estimating the probable life of the alloy under constant temperature conditions.

Table XI presents the result of 100-hr constant temperature tests of various commercial heat resistant alloys (16). It can be seen from these results that the resistance to oxidation in air of NA22H is superior to that of the other commercial heat resistant alloys. However, this is not the whole story. The marked superiority of NA22H shows up when one considers

TABLE XI

Oxidation Resistance of Heat Resistant Alloys 100-Hr Test in Air

	1800 F in. per yr	2000 F in. per yr	2200 F in. per yr	2300 F in. per yr
NA22H	0.0085	0.030	0.045	0.055
25 Cr-12 Ni (HH)	0.025	0.05	0.060	.....
35 Ni-15 Cr (HT)	0.010	0.05	0.15	.....
25 Cr-20 Ni (HK)	0.015	0.035	0.055	.....
60 Ni-12 Cr (HW)	0.010	0.035	0.065	.....
65 Ni-18 Cr (HX)	0.008	0.033	0.06	.....

the cyclic conditions. Table XII presents data obtained from tests conducted under cyclic temperature conditions (17), in which the test samples were heated to 2000 F and cooled daily to room temperature followed by tumbling for 5 minutes. These tests were run for 1000 hr at 2000 F. NA22H was not included in this test. Examination of this data shows that the 65 Ni - 18 Cr alloy, like NA22H, was affected very little by the cyclic temperature conditions. The other commercial heat resistant alloys had the oxidation rates markedly increased by cycling.

Like all high Ni alloys, NA22H is unsuitable for use in reducing flue gases where hydrogen sulphide is present to any appreciable extent, or over 5 gr per 100 cu ft. In the presence of an excess of air, even 100 gr of sulphur per cu ft does not appreciably attack the alloy. However, there always exists the potential danger that a deficiency of excess oxygen may occur, and a serious damaging attack could take place in a very short time.

TABLE XII

Cyclic Oxidation Resistance at 2000 F, 1000-Hr Test in Air

25 Cr-12 Ni (HH)	0.11 in. penetration per yr
35 Ni-15 Cr (HT)	0.116 in. penetration per yr
25 Cr-20 Ni (HK)	0.073 in. penetration per yr
60 Ni-12 Cr (HW)	0.084 in. penetration per yr
65 Ni-18 Cr (HX)	0.035 in. penetration per yr

It should be noted, however, that the presence of sulphur as carbon disulphide (organic sulphur) in amounts up to 40 per 100 cu ft does not affect the alloy even in a severe oxygen deficiency. At 2150 F, in an atmosphere containing 20 per cent combustibles, the rate of attack with the sulphur in this form was less than 0.017 in. penetration per year; even under cycling temperature conditions, the most severe type of service (18). Fifty gr of sulphur per 100 cu ft as hydrogen sulphide attacked the alloy at a rate of 1.56 in. per year in an atmosphere containing only 10 per cent combustibles, and at the same temperature.

TABLE XIII

Thermal Expansion

(Millionths of an In. per In. per F)

100-500 F	7.29
100-600 F	7.40
100-700 F	7.71
100-800 F	7.92
100-900 F	8.02
100-1000 F	8.19
100-1100 F	8.33
100-1200 F	8.41
100-1300 F	8.51
100-1400 F	8.56
100-1500 F	8.60
100-1600 F	8.61
100-1700 F	8.67
100-1800 F	8.75
100-1850 F	8.69

TABLE XIV

Comparative Properties of Heat Resistant Alloys

Temperature, F	NA22H	35 Ni-15 Cr	25 Cr-20 Ni	25 Cr-12 Ni*
	Limiting stress for minimum creep rate of 0.0001 per cent per hr (1 per cent in 10,000 hr)			
1800	2300	2100	2200	1800
1900	1500	1050	1350	....
2000	1050	450	700	700
2100	450	....	230	....
2200	250	....	....	....
	Stress to produce 100-hr rupture life			
1800	5200	4600	4200	4000
1900	3800	....	2850	....
2000	2800	1800	2200	1800
2100	2100	....	900	....
2200	1000	....	....	....
	Stress to produce 1000-hr rupture life			
1800	3600	3200	2700	3000
1900	2350	....	1800	....
2000	1670	....	1100	1000
2100	820	....	520	....
2200	500	....	....	....
	Thermal expansion coefficients—millionths of an inch per inch per F			
100-800	7.92	8.6	9.0	9.6
100-1600	8.61	9.3	9.7	10.3
100-1800	8.75	9.5	10.0	10.5

*Austenitic.

THERMAL EXPANSION

The thermal expansion of NA22H was determined over the temperature range of 100 to 1850 F. Results obtained are presented in Table XIII. The comparative values with other common heat resistant alloys are given in Table XIV. It is pointed out here that the expansion values of this new high temperature alloy is slightly lower than that of the other alloys.

WELDABILITY

This alloy has excellent welding characteristics. Cast rod of the same analysis as the parent castings are coated with a special low hydrogen coating and welded with direct current reversed polarity. No preheat is necessary in welding the standard thin walled (3/8 in. or less) cast forms and the usual technique for the standard commercial heat resisting alloys is used (5). In welding heavier sections, a low heat input and frequent stress relieving by peening may be advisable for extremely intricate shapes. Extensive laboratory and field testing has shown the welds to be equal in high temperature properties to the parent metal.

THERMAL FATIGUE

While the property of thermal fatigue has not been thoroughly evaluated, tests have withstood 250 cycles without fracture. The cycle consisted of heating the specimen to 2000 F and cooling either with CO_2 or air to 150 F once each hour. The apparatus used was as described in the experimental procedure. Service installations have shown no poor results or premature cracking when subjected to thermal fatigue. In fact, the results show the alloy equal to the common commercial alloys. This alloy has not had any service experience as a quenching tray.

COMPARISON OF NA22H WITH OTHER HEAT RESISTING ALLOYS

To facilitate comparison of the properties of NA22H with other commercial heat resisting alloys, a chart was made and is presented as Table XIV. The data presented is an average of published information (7) (8) (9) (10) (11) (12). Study of Table XIV reveals that the creep stress to produce a minimum creep rate of 1 per cent in 10,000 hr is markedly higher for NA22H at temperatures of 2000 F and over. Similarly the 100-hr and 1000-hr rupture life is very much greater than that of the common heat resistant materials, and this holds true from 1800 F up.

APPLICATIONS

All the data presented so far in this paper have been obtained from laboratory experimentation. There is no question that it is next to impossible to reproduce in the laboratory all of the variables which occur in actual mill service. A variety of installations under actual operating conditions was made to prove the practicability of NA22H. The earliest of these was in February of 1947, and the history and benefits derived from a few of these installations follows:

One of the first applications was the installation of 44 radiant tube assemblies in a continuous furnace for the annealing of strip at extremely high temperatures. These tubes were installed in February of 1947, and 33 of the original tubes are still in service. No tubes have been removed due to failure of the alloy in the accepted usage of that term. In all cases, replacement was necessary due to support failure, burner failure or some other mechanical detail. This is noteworthy inasmuch as the average tube operating temperature has been 2000 F, and at intervals the tubes have operated at 2250 F, with a product temperature of 2100 F. It might be noted that several of these tubes operated for a period of at least eight months without support at the return bend end of the assembly, i.e., cantilevered. There was only a slight sag in two of these tubes after this extremely severe service, and these tubes are still in the furnace; a striking example of the rigidity of this material.

Another impressive application of this material has been in the fabrication of retorts for endothermic gas generators. Previous to the use of NA22H, these generators had usual operation temperatures of 1850 F. The new alloy permitted generator operating temperatures of 2050 F to 2100 F, which produced up to 60 per cent more gas without increasing the size of the generator. In addition to the increased capacity, the higher temperature produces a more uniform gas and the life at 2050 F exceeds that of 35 Ni - 15 Cr (HT) at 1850 F. There is a great demand for NA22H for this service.

Another outstanding application illustrates emphatically the economy that can be obtained by the use of this alloy. In a continuous tube annealing furnace operating at a product temperature of 1800 F, the average tube life, using 25 Cr - 12 Ni alloy tubes, was 17 months, with life in some positions of the furnace as low as 9 months. The average length of service of the NA22H tubes installed in this furnace in the most severe locations was 29 months as of May of this year, and all tubes are in excellent condition. In this furnace the oldest NA22H tube has been in operation for 42 months in a position which averaged 13 months with 25 Cr - 12 Ni.

An example which most dramatically illustrates the several advantages to be obtained by the use of NA22H was the substitution of this material in an existing continuous strip processing line. In this installation the factor limiting the output was the heating rate of the strip. The temperature of the furnace section of the line was in turn limited by the life of the commercial radiant tubes. These tubes were made of 25 Cr - 12 Ni alloy, and were only lasting four to six months in the hottest zone of the furnace. NA22H radiant tubes were substituted and the temperature increased resulting in considerable increase in production. It should be emphasized that all of the NA22H tubes which were installed in 1950 are still in service. This increase in temperature also made necessary the redesign of the support rolls. By the use of NA22H, it was possible to design a roll for operating at a furnace temperature of

2000 F which was actually cheaper than the previously used $^{35}/_{15}$ roll designed for 1800 F. This was made possible by the greater strength of NA22H. Thus we see in this one installation NA22H made possible: (a) increased production due to the use of a higher heat head, (b) use of less alloy operating at a higher temperature, and (c) economy in operation due to lower maintenance.

The remarkable strength of NA22H over other heat resisting alloys can also be seen in another case history. Bars for supporting baffles in a steam superheater were averaging three months life by which time the alloy sagged so badly that marked shifting of the baffle plates resulted. The customer had tried 25 Cr - 12 Ni, 25 Cr - 20 Ni and various other alloys. Space limitation in the super-heater prevented redesign of the support bars. In 1948, NA22H bars were installed as a straight material substitution and these supports are still in operation.

Copper brazing of steel was one of the earliest high temperature processes to which continuous furnaces were applied. This operation is carried on at a temperature of 2050 F which requires furnace temperatures of 2100 F or higher in a neutral atmosphere. Most continuous furnaces are heated with electric heating elements. In a particular installation, the roof elements were supported on 35 Ni - 15 Cr alloy beams spanning the furnace. There being very limited space between the bottom of the beams and the top of the work passing through the furnace, obviously only slight sagging of the beams could be tolerated. In a very short time, 35 Ni - 15 Cr proved inadequate. Again the space limitations made redesign of the beam impractical. Many materials were tried, including silicon carbide and 25 Cr - 20 Ni, but the thermal shock due to cold work passing under the beams intermittently, defeated them all. NA22H was substituted and gave a much greater life. Furthermore, it was found that when the warpage near the charge end of the furnace exceeded the maximum deformation permissible, beams of this material could be straightened, and when reinstalled in the furnace gave equivalent life when compared to that of their original installation.

An unusual application was the installation of a cast NA22H high temperature, high speed recirculating fan in a closed muffle type furnace. This fan was designed for operation at 2200 F with a stress of 150 psi. It has been in service since 1949.

A very recent application has been the installation of two roller hearth furnaces for heat treating diaphragms for jet engines at 2150 F. By using this new high temperature alloy, a substantial savings resulted in both alloy and space. Had these furnaces been designed using 35 Ni - 15 Cr shafts, they would have required twice as many furnaces.

In the past year, installations of NA22H for muffle furnaces has been made. These furnaces are being used for heat treating in a protective atmosphere such items as sintered carbides, stainless steel and for brazing with work temperatures in excess of 1900 F. Previous use of 67 Ni - 17 Cr alloy for these muffles gave poor results. As of now, the NA22H muffles are working satisfactorily.

An application, involving resistance to oxidation alone, was made for a new designed soaking pit burner. Here the alloy casting is on the soaking pit wall and subjected to radiation from the soaking pit temperature. The first installation was put into operation in December, 1950, and is still in service. Additional installations have since been made.

The use of NA22H for pier caps and rails in a rotary type furnace where product temperature is 1900 F has resulted in over three years service. The alloy which is supporting coils of alloy wire is still in excellent condition.

Recently other industrial applications of NA22H have been installed for roller rails, trays, work supports and hearth plates. While the service life at present is not long enough to give histories, all indications are that they will be very satisfactory. While the above list of service histories does not cover all applications of NA22H to date, they were chosen to illustrate some of its possibilities.

SUMMARY

The evidence, both from field and laboratory tests, which has been presented in this paper clearly demonstrates the superiority of NA22H over the commonly used commercial heat resistant alloys, in certain applications, at temperatures from 1800 F to 2200 F. Positive economical advantages have been proven in industrial installations. It permits practically engineered designs for temperatures up to 2200 F, which represents an increase of 200 F over previous maximum temperatures.

In conclusion, the use of NA22H will permit: (1) increased furnace capacity and efficiency by increasing the rate of heating through use of higher heat heads, (2) practical engineering design to temperatures to 2200 F, and (3) longer alloy life per dollar invested.

BIBLIOGRAPHY

1. "*High Temperature Alloys*," by FREEMAN, REYNOLDS, WHITE, A.S.T.M., 1946.
2. "*Mechanism of Rapid Oxidation of High Temperature, High Strength Alloys Containing Molybdenum*," by LESLIE and FONTANA, A.S.M. Trans. 1949, p. 1213.
3. "*Accelerated Oxidation of Metals at High Temperature*," by BRASUNAS and GRANT, A.S.M. Trans. 1952, p. 1117.
4. "*Progress Report No. 25 on Alloy Castings for High Temperature Service to Alloy Casting Institute*," May, 1946.
5. "*High Temperature Welded Joints*," by R. H. ENGLISH, Welding Journal, October, 1951.
6. "*Creep Testing by a Cantilever Bending Method*," by HARRIS and CHILD, Journal of the Iron & Steel Institute, 1950.
7. Metals Handbook, A.S.M. 1948, p. 570-579.
8. A.C.I. Bulletin No. 9, 1946.
9. A.C.I. Bulletin No. 11, 1947.
10. "*Cast Heat Resistant Alloys of the 16% Cr-35% Ni Type*," by AVERY and MATTHEWS, A.S.M. Trans. 1947, p. 957.
11. "*Cast Heat Resistant Alloys of the 26% Cr-20% Ni Type*," by AVERY and WILKS, A.S.M. Trans. 1948, p. 529.
12. "*Balancing the Composition of Cast 25% Cr-12% Ni Type Alloys*," by GOW and HARDER, A.S.M. Trans. 1942, p. 855.
13. "*The Use of Creep Data in Design*," by CROSS and JACKSON, A.S.T.M. Publication 107, Nov. 1950.
14. "*The Cyclic Temperature Acceleration of Strain in Heat Resisting Alloys*," by BROPHY and FURMAN, A.S.M. Trans. 1942, p. 1115.
15. "*Theory of Flow and Fracture of Solids*," by NADAI, McGraw-Hill 1950, p. 353.
16. "*Resistance of Iron-Nickel-Chromium Alloys to Corrosion in*

Air at 1600 to 2200 F," by BRASUNAS, GOW and HARDER, Proceeding A.S.T.M. Vol. 46, 1946.

17. "*Progress Report No. 28 on Alloy Castings for High Temperature Service to Alloy Casting Institute*," June 10, 1947.

18. "*Progress Report No. 31 on Alloy Castings for High Temperature Service to Alloy Casting Institute*," 1949.

DISCUSSION

PRESENTED BY

W. H. DAILEY, JR., Surface Combustion Corp., Toledo, Ohio

M. N. ORNITZ, Works Manager, National Alloy Steel Div., Blaw-Knox Co., Blawnox, Pa.

A. M. TOHIR, Design Engineer, United States Steel Corp., Irvin Works, Dravosburg, Pa.

N. A. MATTHEWS and C. R. WILKS, American Brake Shoe Co., Mahwah, N. J.

R. H. ENGLISH, Chief Metallurgist, National Alloy Steel Div., Blaw-Knox Co., Blawnox, Pa.

W. H. Dailey: This paper has been of great interest to us because of the data presented for other alloys as well as for NA22H. We seldom see test data for so many cast heat resisting alloys taken under comparable conditions. This is also the first time we have seen data on cyclic oxidation of the various commonly used high temperature alloys.

We believe that the authors have made a very much needed contribution of practical design information for those of us who design and use high temperature structures and machinery. We have worked with this alloy since early in its development, and have used it for radiant tubes, retorts, fans, and other mechanical and structural parts.

In many cases we have found that its structural stability and oxidation resistance are markedly superior to other chrome-nickel alloys, even at lower temperatures, and on an economic basis it can replace them for many applications in the 1700-1900 F range.

For example, in continuous strip processing lines which are expected to operate for several years without major maintenance, a frequent cause for failure of strip support rolls is warping due to accidental stopping or overheating. The greatly increased safety factor available with NA22H usually greatly reduces or eliminates outages due to this cause.

This alloy is particularly well suited for construction of tubes for fuel-fired radiant heating elements in high temperature atmosphere furnaces. Desirable features for such service are, first, resistance to cyclic oxidation; second, resistance to thermal shock, and third, high temperature strength.

The availability of materials for construction of fuel-fired heating elements in the range of 2100-2200 F brought forward a whole series of new problems for the designers of industrial furnaces.

By increasing the furnace temperatures, the heat transfer rates were very much increased, since radiation heat transfer varies as the fourth power of the temperature. Consequently, the emission of heat per square foot of radiant heating element increased approximately 50 per cent when the operating temperature was increased from 1800 to 2100 F. To take advantage of this, increased combustion capacity was required.

At the higher fuel inputs, initial ignition had to be speeded up, but once established, combustion rates were very high, and to avoid local overheating, means had to be provided to give uniform heat emission over the length of the heating element. The problems of sealing the heating elements against atmosphere leakage and provision for disposal of the waste gases were accentuated.

To take full advantage of the increased heating rates possible with high temperature radiant heating elements, it was necessary to work out temperature control techniques which would allow operation near the upper safe limit at very high fuel inputs, and would at the same time avoid local overheating and overshooting of temperatures.

In general, this was accomplished by measuring the heating element temperature, instead of the average furnace temperature as normally done, and by providing for uniform fuel input to all heating elements in a group.

In our company, the solution of these problems resulted in much simpler and improved designs for burners, gas-tight mounting structures, exhaust gas disposal and temperature control systems. Many of these improvements were applicable to lower temperature heating elements.

We wish to compliment the authors of this paper for the complete information on their test methods and results, and particularly for making simultaneous tests on other standard high temperature alloys. We also wish to take this opportunity to present some questions and suggestions for further test work in this field.

First, published data for high temperature strength, particularly for 1 per cent creep in 10,000 hours, which is about 1 per cent deformation in a year, frequently does not agree. For example, two sets of published data will show 50 per cent different strength for the same alloy at the same temperature. When comparing wrought and cast alloy, published data sometimes shows the cast alloy to be three times as strong. We question this, and wonder what is the explanation.

Second, we are making increased use of the high temperature alloys for construction of machinery with sliding and rolling parts operating without lubrication at temperatures from 1200 to 2200 F. We have some roller bearings in the 1000-1200 range operating successfully with 0.005 in. tolerance.

To extend the use of this type of machinery we need to know more about sliding and rolling friction of high temperature materials, in air, in flue gases and in reducing atmospheres such as hydrogen. We also need to know more about the proper composition and heat treatment for maintaining dimensional stability over a long period of time.

M. N. Ornitz: Mr. Dailey has brought up several interesting aspects in his discussion of the use of NA22H from the furnace manufacturers and users point of

view. It is quite true that under many applications at lower temperatures such as 1700-1900 F range, the use of such an alloy would give added factors of safety and permit lower maintenance and less outage time. We have not stressed that point due to the shortage of nickel at this time, and the need therefore to use this allow only on those applications where no other alloy would be feasible, or which would show an immediate overall savings. Later when melting restrictions are lowered, it would be possible to use this material with a long-range point of view of lowering costs.

With regard to Mr. Dailey's first question on the discrepancy of published data on high temperature strength for 1 per cent in 10,000 hours, it is unfortunately true that a large amount of erroneous information has been published. A good deal of this can be attributed to poor testing technique, particularly in temperature control. In addition, some heat resistant alloys show a wide spread between one heat and another. This difference, however, is not as great as is sometimes published. Data presented on commercial alloys in our paper is an average of the known reliable data supplemented by data obtained by test results in our own laboratory.

The strength difference between wrought versus cast materials is well known. It has long been proven that cast materials in general are markedly stronger in creep than wrought materials. This is primarily due to the mechanism by which creep takes place, large grain size being more resistant to this phenomenon than fine grain size. In addition, cast materials have a slight difference in composition than that of wrought materials. This also contributes to their markedly higher strength. The effect of grain size can be shown by a rolled material such as inconel. At 1600 F, coarse grain inconel has a creep strength of approximately 2000 psi for 1 per cent elongation in 10,00 hours, while in the cold drawn and annealed condition, the same material at this same temperature has a limiting creep strength for 1 per cent in 10,000 hours of approximately 810 psi. The difference between wrought and cast materials can further be shown by comparing figures presented in ASTM publication 124 for wrought materials which are hot rolled and annealed with that of cast materials. For example, on a 1000-hr rupture life at 1800 F, wrought 25 Cr - 12 Ni type material will require a stress of 1050 psi, whereas cast material would require a stress of 3000 psi to fail in 1000 hours. The same comparison can be made on other heat resistant materials with various ranges of temperature.

Mr. Dailey's second question with regards to sliding friction for rollers and similar applications has not been fully evaluated. However, we do know from our experiments that at temperatures of 1800 F and higher, that the factor of sliding and rolling friction becomes less prominent due to the nature of oxide formed. We do not have sufficient data to cover this subject, and it is a good direction in which experimental work could be done. The problems of developing new alloys and running extensive engineering tests over a period of years involves expensive equipment and considerable amount of manpower and money. Although considerable amount of work has been done, there are a great number of fields to be investigated for cast materials particularly of the heat resisting type.

A. M. Tohir: You have mentioned numerous applications for your new high temperature, high strength alloy. One application, not specifically mentioned, however, is its use for inner covers in high temperature gas-fired furnaces operating with a protective atmosphere.

Furnaces of this type are being used for products requiring treatment at temperatures above 200 F. The furnace inner covers must be cast in segmental sections and welded to form a gas-tight enclosure.

Oxidation resistance under cycling conditions, thermal expansion, and weldability of the metal all appear to be critical factors in this application.

What has been your experience with this type of inner cover?

M. N. Ornitz: In reply to Mr. Tohir's question, one of the most difficult fabricating applications that we have made of NA22H was that on a muffle 48 in. in diameter and 96 in. high. This muffle, which is tangently fired with the flame impinging on the base, is used for heat treating coils with product temperature of around 2050 F. This flame impingement in the vicinity of the burner sets up extremely high thermal stresses. Mechanical damage that has been experienced on this muffle has been readily repaired and muffle has been in service since 1950. Prior to its application, a muffle made out of 25 Cr - 20 Ni was used and gave very short service life. We have had similar experience on smaller covers used for experimental purposes for heating in a controlled atmosphere at temperatures of 2100 F. The subject covers were installed in 1948 and are still in service and have been used extensively.

N. A. Matthews and **C. R. Wilks:** The authors are to be complimented on a thorough survey of a new material which is promising for a wide range of high temperature applications. We have followed the field tests of the NA22H type alloy and agree that it fills an important need and will be helpful in extending the application of heat resistant alloys in industrial furnaces toward the 2200 F level which has presented a challenge for some time.

We suggest one area that merits discussion and that is the strength comparison of NA22H with the HK (25 Cr - 20 Ni) type alloy. It is unfortunate that a relatively weak heat of the HK type was the only basis of comparison, because our research over the last nine years has demonstrated that the carbon level in the HK type should be considerably higher to realize maximum hot strength at and above 1800 F. The preferred carbon level is 0.50 per cent and our data and field experience indicate that excellent properties are obtained over the practical working range of 0.45 to 0.55 per cent carbon.

Applications have included furnace dry-shafts, conveyor chain, carrier blades, radiant tubes, supports, beams and other miscellaneous furnace parts where operating temperatures exceed 1800 F. The alloy can be welded, cold straightened and generally processed similarly to the conventional HK and HH (25 Cr - 12 Ni) type alloys.

Detailed hot strength data from several heats are shown in Table XV and a scatter band plot comparing the data with the NA22H type appears as Figure 13

TABLE XV

Summary of Properties — HK (26 Cr: 20 Ni) Alloys with 0.40/0.60 Per Cent Carbon

Heat No.	Composition, per cent						Room temperature properties				Creep and stress-rupture properties											
							As cast		Aged 1400 F-24-FC		1800 F				2000 F				2200 F			
	C	Mn	Si	Cr	Ni	N	Tensile strength, psi	Elongation, per cent	Tensile strength, psi	Elongation, per cent	Stress, psi	Life, hr	Rate, per cent per hr	Elongation, per cent	Stress, psi	Life, hr	Rate, per cent per hr	Elongation, per cent	Stress, psi	Life, hr	Rate, per cent per hr	Elongation, per cent
45-730	0.42	1.06	2.21	26.1	20.1	0.13	73000	19.5	77250	4.0	6000	18.9	0.22	24	4000	6.2	0.46	16	1500	6.2	1.4	24
											4000	326.	0.0017	5	2500	103.	0.002	9	500	577	<0.0037	25
47-506	0.42	0.96	2.30	26.1	19.6	0.14	76000	16.5	80000	5.0	6000	31.0	0.062	10.5								
											4000	265.	0.0031	2								
											3000	1026(d)	0.00016	(0.21)								
47-973	0.44	1.02	1.28	26.0	20.2	0.11					6000	68.9	0.0088	5	4000	12.8	0.044	2				
											6000	59.2	0.021	6	4000	18.5	0.041	4				
											3000	1058(d)	0.0001	(0.17)								
47-103	0.46	1.26	1.32	26.3	19.9	0.05	73750]	21.0	82500	6.5	6000	33.0	0.074	17	4000	10.5	0.41	21				
XK-108	0.47	1.03	1.25	26.8	20.0	0.15	76000	18.0	83250	3.5	6000	49.4	0.088	16	4000	14.7	0.18	11	1500	7.6	0.36	15
											4000	300.	0.0009	1.0	2500	109.	0.0018	3	1000	32.4	0.04	9
											3000	1002(d)	0.00005	(0.11)	1500	753(d)	0.00017	(0.35)	500	524.	0.0012	17
															800	1490(d)	0.000035	.....	300	7582(d)	0.00014	(47)
47-020	0.50	0.99	1.25	26.2	20.1	0.05	72750	14.0			6000	28.6	0.088	13					1000	40.	0.041	9
																			500	312.	0.00048	12
																			300	2782	0.00041	35
45-731	0.54	1.09	2.33	24.5	20.5	0.12	68000	6.0	78750	2.5	6000	34.9	0.064	21	2500	139	0.0028	5				
46-846	0.56	0.91	1.23	26.2	19.9	0.05	74250	10.5			6000	37.5	0.057	10								
45-734	0.60	1.09	2.20	26.4	19.8	0.12	71250	7.0	76500	2.5	6000	42.1	0.046	15	4000	8.8	0.38	25	2000	3.2(d)	4.2	(44)
											4000	547	0.0012	5	2500	134.	0.0037	16	1500	14.2	0.50	30
											3000	1728	0.00038	2	1500	1214.	0.00011	7	1000	76.4	0.018	13
															1000	2110.	0.00014	9	500	594 ± 22	0.0012	15
																			300	2920(d)	0.00007	(16.5)
45-735	0.61	1.10	1.12	26.5	20.3	0.13	74750	9.5	83750	2.5	6000	75.4	0.031	11	4000	14.3	0.17	14	1500	16.2	0.14	15
															2500	255.	0.0021	6	1000	59.3	0.0032	7
															2000	258 + 21	0.0025	2.5	500	636(d)	0.0002	(9.6+)
															1000	1172(d)	0.00005	(0.08)	300	1264(d)	<0.00003	(3)

d = discontinued before fracture

which shows the HK (26 Cr - 20 Ni) alloys at about 0.50 per cent carbon to have comparable, and quantitatively slightly but perhaps not significantly superior, hot strength in the 1800 F-2200 F range, based on conventional creep strength considerations.

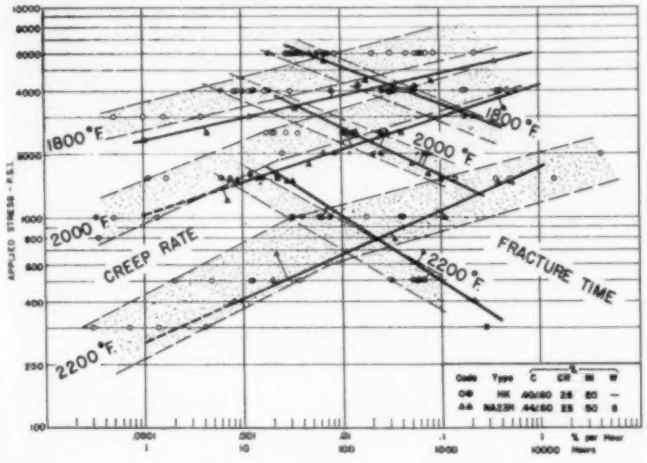


Figure 13 — Comparison of creep and stress rupture characteristics of HK and NA-22H alloys.

It is our opinion that further testing of the NA22H alloy is required to substantiate the implied stability in the higher temperature ranges. We readily admit that the HK50 grade, while considerably stronger than the standard alloys used by the authors for comparative purposes, is unstable above 2000 F on two easily recognizable counts. First, there is generally a departure from linearity in the logarithmic stress-rate plot, the break occurring at about those stresses that produce creep rates of the order of 0.001 per cent per hour. Secondly, particularly at 2200 F, even at stresses that produce minimum creep rates of the order of 0.0001 per cent per hour and below, these minimum rates (i.e., Stage 2) persist for much shorter times than obtain for similar stress-rate conditions at 1800 F, for example. In the absence of the time-elongation (creep) curves, which the authors have justifiably omitted, examination of the creep data of Table IV suggests

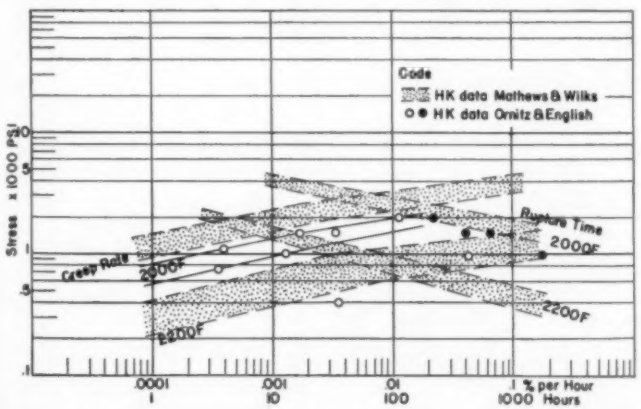


Figure 14 — Comparison of creep and stress rupture characteristics for HK alloy.

that the NA22H is not wholly stable in the latter respect. Where carried to fracture, further comment would be superfluous, but in the few instances where this did not occur, attention is directed to the magnitude of the total deformation or elongation during creep in comparison with the reported minimum rate. Evaluation of the NA22H alloy, with reference to the type of instability manifested by non-linearity in the stress-rate plot, requires further testing at these higher temperatures under applied stresses that will produce secondary or minimum creep rates of the order of 0.0001 per cent per hr.

In brief, it is our opinion that, in terms of hot strength alone, the HK (26 Cr - 20 Ni) alloy at 0.50 per cent carbon is comparable to the NA22H alloy, and that under service conditions where this factor alone is paramount, comparable performance might be expected. We do not contend nor wish to imply that these two grades are necessarily comparable in other respects. Particularly where resistance is required to carburizing conditions or to thermal fatigue, when cyclic temperature fluctuations obtain, the NA22H alloy, in view of its higher nickel content, would be expected to provide superior performance. Conversely, the HK alloy, with its lower nickel content, should be the more logical choice in the presence of sulphurous gases that rapidly deteriorate the higher nickel materials.

M. N. Ornitz and R. H. English: Mr. Matthews and Mr. Wilks have presented some interesting points in their discussion. It might be well to mention the primary reason for not discussing the high carbon levels of 25 Cr - 20 Ni type alloy is that the results published heretofore have varied considerably with our own laboratory results. We feel there is a need for further evaluation of this alloy before data on this be published. However, at 0.30 per cent carbon level, the data

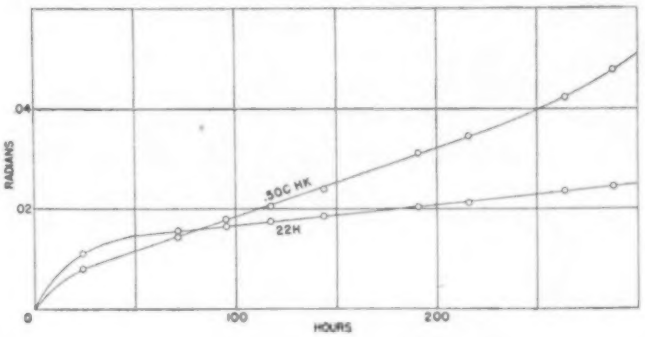


Figure 15 — Time-deformation curve by cantilever creep test at 2000 F and 1750 psi.

published agreed substantially with that obtained in our own laboratory, and this data was presented in our paper. To illustrate this discrepancy, Figure 14 is presented showing the scatter band plot of Mr. Matthews and Mr. Wilks and results obtained in our own laboratory. We also show a wide scatter band for this material, but do not show the strengths that they attribute to it. In addition, the departure from linearity in the logarithmic stress rate plot was obtained at approximately the same rate as that shown by their data. Table XVI presents the composition, creep, and stress rupture data of these tests.

The fact that the 0.5 per cent carbon HK alloy is not as strong as NA22H at temperatures of 2000 and 2200 F can be clearly shown by cantilever beam test results which are presented as Figures 15 and 16 for tempera-

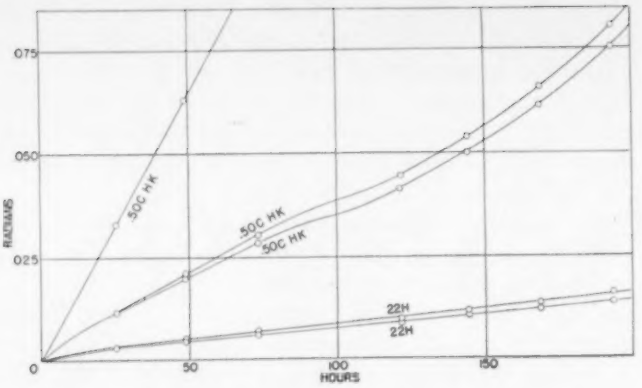


Figure 16 — Time-deformation curve by cantilever creep test at 2200 F and 500 psi.

tures of 2000 and 2200 F. The composition and rates of the alloys tested in these cantilever creep tests are presented in Table XVII. Again we see just as was shown for low carbon 25/20 material that this alloy at a 0.5 per cent carbon level has a very short stage of

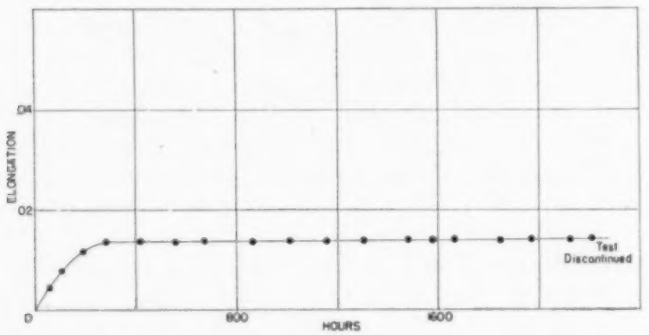


Figure 17 — Time-deformation curve by tensile creep test for NA-22H at 200 F and 200 psi.

steady creep at these stresses, and, in addition, deformation rates in excess of that of NA22H.

The stability of NA22H, which has been fully demonstrated in the many applications in which it has been used, can also be shown from laboratory data of time-deformation curves. These were not included in the paper because it was felt they were extraneous. However, we are presenting as Figures 17 and 18, two such curves at 2200 F to show stability of this alloy, and further to explain the magnitude of total deformation as compared to minimum creep rate. The creep and stress rupture data of these tests are shown in Table XVIII. Figure 17 is that of a stress of 200 psi at 2200 F which gives a minimum creep rate less than that of 1 per cent in 10,000 hours and after 2261 hours when the test was discontinued it was still in the steady stage of creep (stage 2). Figure 18 at a stress of twice this magnitude shows that when this alloy enters stage 3, its ductility is extremely high so that marked elongation occurs long before fracture. This condition is characteristic of most of the high nickel alloys, but not of 25/20 grade material.

It is quite true as Mr. Matthews and Mr. Wilks have mentioned that at temperatures over 2000 F, there is a structural instability in 25/20 grade material. This

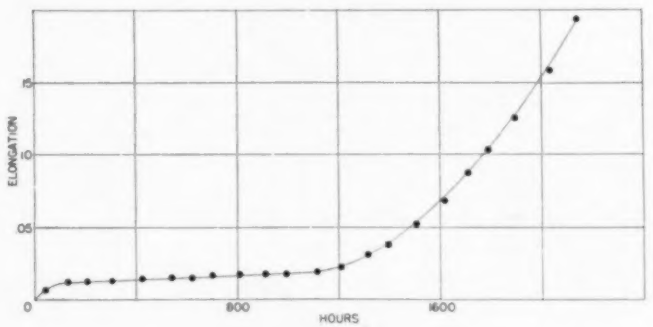


Figure 18 — Time-deformation curve by tensile creep test for NA-22H at 2200 F and 400 psi.

does not occur in NA22H. Taking the minimum creep rate of 0.000035 per cent per hr for a stress of 200 psi at 2200 F and adding this point to the 2200 F curve reveals there is no departure from linearity on the stress

TABLE XVI

Creep and Stress Rupture Test Data — 0.5 Per Cent C HK

Heat	Temperature, F	Stress, psi	Duration, hr	Minimum rate, per cent per hr	Elongation, per cent	Reduction in area, per cent
424232	2000	750	1654 no fracture	0.00036	.....	.....
424232	2000	1000	1750	0.0013	6	9.6
424232	2000	1500	406	0.0034	10	24
217042	2000	2000	220.5	0.0112	5.6	13.5
217042	2000	1500	656	0.0017	9	20.2
432951	2000	1100	750 no fracture	0.0004	.....	.....
424232	2200	967	85.5	0.043	22.0	17.7
424232	2200	400	164 test discontinued	0.0036	.....	.....

Chemical Analysis of Test Heats

Heat	C	Mn	Si	Ni	Cr
424232	0.50	1.05	1.71	18.5	27.9
217042	0.59	1.92	1.08	21.6	26.0
432951	0.46	1.60	1.79	21.1	25.0

TABLE XVII

Cantilever Creep Results — 2000 F — 1750 Psi

Alloy	C	Mn	Si	Ni	Cr	W	Minimum creep rate, radians per hr
NA22H	0.59	1.50	1.08	48.6	28.5	4.91	0.000039
0.5 per cent C HK	0.50	1.25	1.27	19.9	27.6	.....	0.000137

Cantilever Creep Results — 2200 F — 500 Psi

Heat	Alloy	C	Mn	Si	Ni	Cr	W	Minimum creep rate
3203	0.5 per cent C HK	0.56	1.05	1.46	20.8	26.6	.....	0.0013
3212	0.5 per cent C HK	0.52	1.12	1.50	19.4	25.9	.....	0.00036
3214	0.5 per cent C HK	0.55	1.09	1.27	19.9	25.6	.....	0.00039
3204	NA22H	0.48	1.21	1.28	46.9	27.9	5.07	0.000066
3213	NA22H	0.52	1.15	1.11	46.7	27.2	5.04	0.00007

TABLE XVIII

Chemical Analysis and Creep and Stress Rupture Data — 2200 F

Heat	Alloy	C	Mn	Si	Ni	Cr	W	Stress, psi	Minimum rate, per cent per hr	Duration, hr
422684	NA22H	0.51	1.34	1.18	45.6	25.9	5.89	200	0.000035	2261 no fracture
422684	NA22H	0.51	1.34	1.18	45.6	25.9	5.89	400	0.0008	2156

rate plot of Figure 4. There are very few cases where hot strength without structural stability would be of value in service where long-time service life is required. However, we feel that there is a definite application for the HK material particularly at temperatures up to 2000 F.

AID DEFENSE

MORE SCRAP TODAY . . . .

MORE STEEL TOMORROW.

GET IN THE SCRAP TO KEEP STEEL COMING.

NON-FERROUS SCRAP IS NEEDED TOO!

CURRENT AISE DISTRICT SECTION MEETING NOTICES

BIRMINGHAM SECTION

Monday, March 30, 1953 — Dinner 6:30 P.M., Meeting 8:00 P.M.

"Application of Magnetic Amplifier," by Paul M. Fischer, Electrical Engineer, Research Department, Cutler-Hammer, Inc., Milwaukee, Wisc.

Thomas Jefferson Hotel, Birmingham, Ala.

▲

BUFFALO SECTION

Tuesday, March 10, 1953 — Dinner 6:30 P.M., Meeting 8:00 P.M.

"Rehabilitating Blast Furnace and Associated Operations," by W. C. Daniels, Superintendent Mechanical Dept., Bethlehem Steel Co., Lackawanna, N. Y.

Hotel Sheraton, 715 Delaware Ave., Buffalo, N. Y.

▲

CHICAGO SECTION

Tuesday, March 3, 1953 — Dinner 6:15 P.M., Meeting 7:45 P.M.

"Steel Mill Communications," by W. G. Rowbotham, Illinois Bell Telephone Co., Chicago, Ill.

Phil Smidt's Restaurant, 1205 N. Calumet Ave., Hammond, Ind.

▲

CLEVELAND SECTION

Monday, March 16, 1953 — Dinner 6:30 P.M., Meeting 8:00 P.M. at Youngstown*

Tuesday, March 17, 1953 — Dinner 6:30 P.M., Meeting 8:00 P.M. at Cleveland*

*Note switch in dates between Cleveland and Youngstown.

"Labrador-Quebec Iron Ore Development," by M. Bradley, Public Relations Dept., M. A. Hanna Co., Cleveland, Ohio

Cleveland — Coytons Marine Dining Room, 508 W. Superior Ave., Cleveland, Ohio

Youngstown — El Rio Club, Youngstown-Warren Rd., Route 422, Youngstown, Ohio

▲

DETROIT SECTION

Tuesday, March 10, 1953 — Dinner 6:30 P.M., Meeting 8:00 P.M.

"Labrador Iron Ore Development," by John A. Jones, Director of Public Relations, and Ted Varner, Chief Photographer, Weirton Steel Co., Weirton, W. Va.

Horace Rackham Educational Memorial, Detroit, Mich.

▲

PHILADELPHIA SECTION

Saturday, March 7, 1953 — Dinner 6:00 P.M., Meeting 7:00 P.M.

"Causes and Prevention of Premature Gear Failures," by Rankin Johnson, Jr., President, R. Johnson Co., New York, N. Y., and S. D. Craine, Engineer, W. A. Jones Foundry and Machine Co., Chicago, Ill.

Discussion by:

Wm. G. Bewley, Assistant Superintendent, Electrical Mechanical Maintenance, Alloy and Tool Steel Division, Bethlehem Steel Co., Bethlehem, Pa.

C. H. Burden, Chief Project Engineer, John A. Roebling's Sons Co., Trenton, N. J.

W. E. Matthews, Assistant Superintendent, Mechanical Department, Bethlehem Steel Co., Sparrows Point, Md.

W. J. Metcalf, Technical Assistant to Superintendent, Mechanical Department, Lukens Steel Co., Coatesville, Pa.

Engineers' Club, 1317 Spruce St., Philadelphia, Pa.

▲

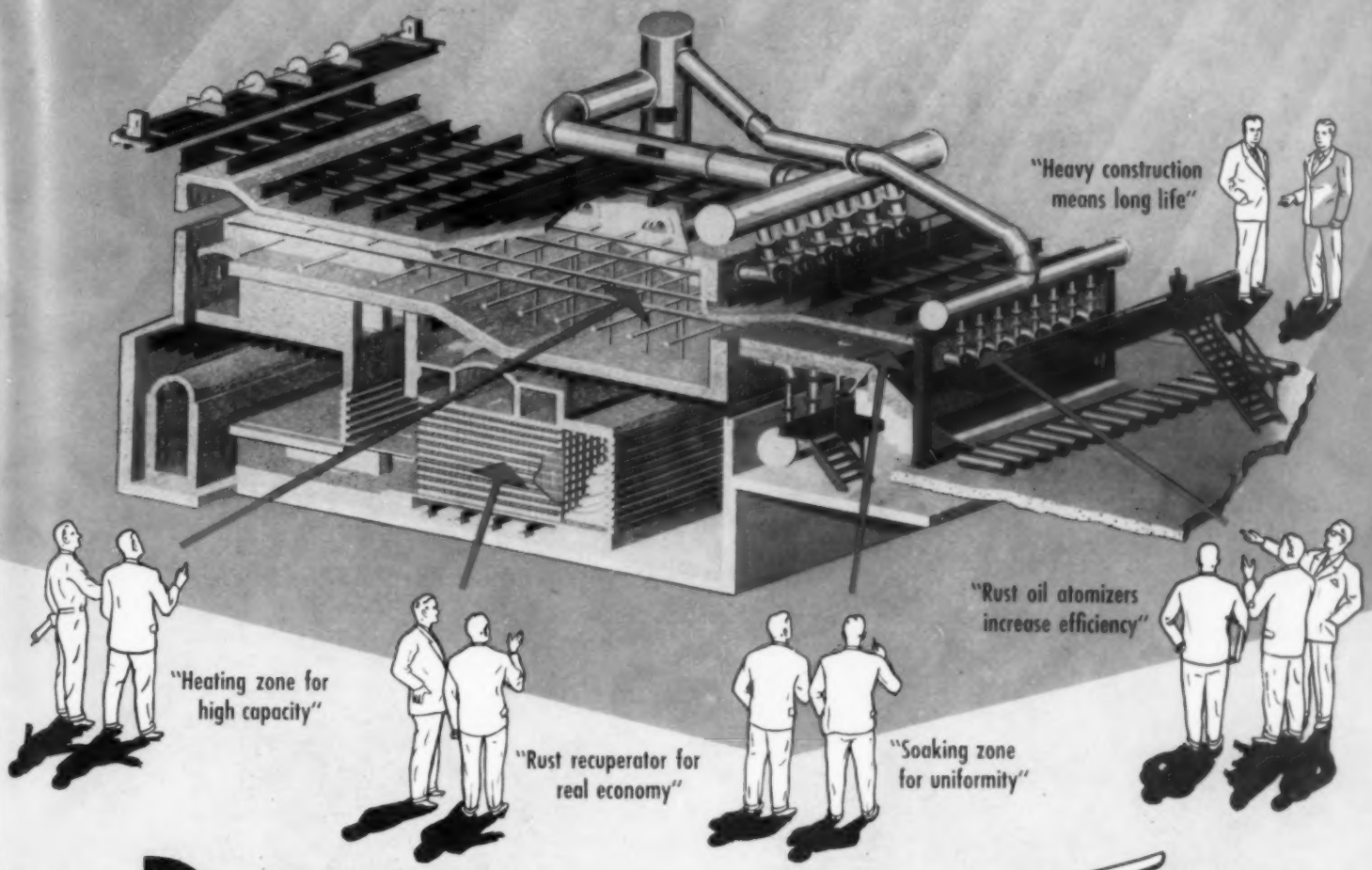
PITTSBURGH SECTION

Monday, March 9, 1953 — DINNER 7:00 P.M., Meeting 8:00 P.M.

"Gas Turbine's Place in Industry," by T. J. Putz, Manager, Gas Turbine Engineering, Westinghouse Electric Corp., Philadelphia, Pa.

University Club, University Place, Pittsburgh, Pa.

FURNACE MEN KNOW THEY'RE BETTER


"Heavy construction means long life"
"Heating zone for high capacity"
"Rust recuperator for real economy"
"Soaking zone for uniformity"
"Rust oil atomizers increase efficiency"

RUST *Continuous Reheating Furnaces*

PROVIDE ACCURATE *TEMPERATURE CONTROL*.. FOR SLABS, BLOOMS, BILLETS, BARS, ETC.

Yes, furnace men know the advantages of Rust's patented zone controlled, double or triple-fired, recuperative, continuous furnaces. They give positive, automatic control of heating quality and tonnage output. Each furnace is individually designed to meet specific needs and provides 100% accuracy in the control of predetermined heating temperatures. Flexibility is achieved by simply changing the fuel firing rate in the heating zone. It means maximum heating efficiency with a minimum of fuel.

In addition to reheating furnaces, Rust builds other types (designed for any fuel) for practically all metallurgical heating needs. For either new or modernization projects let Rust quote on your requirements.

THE WHOLE JOB IS ONE JOB WITH A

RUST "PACKAGE" CONTRACT

One contract covers everything ... from blue print through start up. Rust assumes responsibility for design, manufacture, erection, and is prepared to undertake all phases of the work with its own forces, including wiring and piping. This results in substantial savings ... One profit instead of pyramiding ones which accrue where many subs are employed.

RUST FURNACE COMPANY

Pioneers in Furnace Design

RUST BUILDING PITTSBURGH, PA.

INDUCTION STIRRER FOR ARC FURNACE

By ERIC G. MALMLOW
President
Aros Electric Co.
New York, N. Y.

and

QUENTIN GRAHAM
Vice President
Elliott Co.
Ridgway, Pa.

▲ THE recent installation at the Timken Roller Bearing Co. of a 100-ton electric arc furnace equipped with an induction stirrer marks the beginning of a new era in electric-furnace steel making in this country. The principles of stirring the molten metal by inductive means has been established abroad as being sound economically. In Swedish installations, marked improvements have been noted in overall production time, and in the quality and uniformity of the steel.

The metallurgical benefits of these early installations have been described elsewhere [1], [2], [3], and more data will undoubtedly become available on the current installation as further experience is gained.

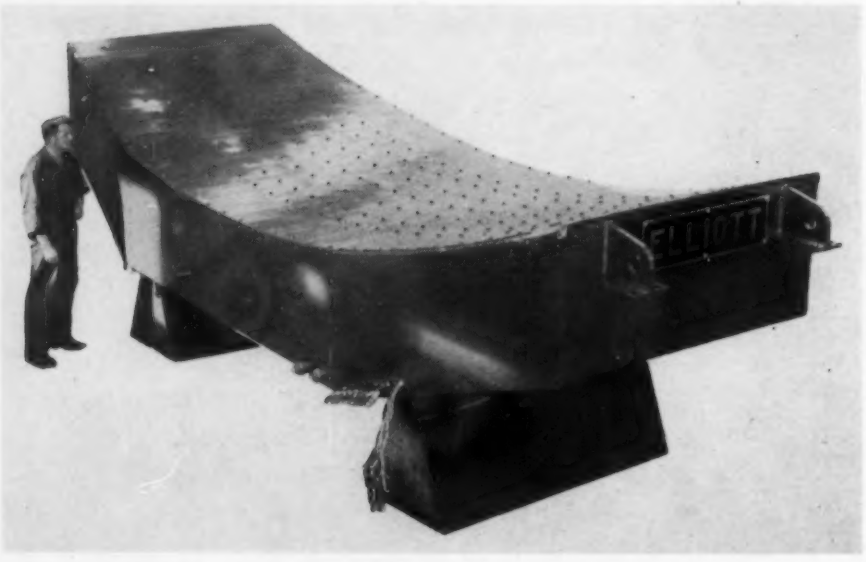
Briefly, the principal benefits are a saving in time required per melt, largely because of faster reactions between steel and slag; a much easier slagging-off operation; a more uniform temperature in all parts of the mass, as well as a more rapid distribution of alloying elements, thereby making certain that samples are more nearly representative of the entire melt. The uniformity of the finished product, its cleanness and its closer tolerance to specifications are among the more important advantages of thorough stirring.

The stirrer was invented and developed by ASEA, the largest electrical manufacturing works in Sweden, under the guidance of Dr. L. Dreyfus. The first installation of this type of stirrer was at the Surahammar steel works in Sweden in 1939. The second was at the Hagfors Works in 1947. The first Surahammar stirrer confirmed the principle, but had operating difficulties which required its being removed from service. In 1948, a second stirrer was installed at Surahammar and is still operating successfully. Several additional stirrers have since been ordered for other European steel plants and some are already in operation.

During the latter part of 1950, an agreement to manufacture the stirrers in this country was made between Aros Electric, Inc., of New York, and the Elliott Co. Aros Electric, Inc., is a wholly owned subsidiary of ASEA and the induction stirrer is being marketed through this organization. The present stirrer at Timken is the first to be installed. It was built at the Ridgway Division of the Elliott Company.

The stirrer, which is shown in Figure 1, has been described as a segment of the stator of a gigantic induction motor. It is wound for 2-phase supply and consists of two magnetic poles. The power supply is of very low frequency so the magnetic field travels over the surface at the most suitable speed and penetrates well into the molten metal in the furnace.

Figure 1 — Shop view of completed induction stirrer gives some conception of the relative size and contours necessary to serve the 20-foot electric furnace.



In the 20-ft diameter Heroult furnace, built by the American Bridge Division, United States Steel Corp., the bottom is spherical with a 1-¼-in. bottom plate of stainless steel, selected for its non-magnetic characteristics. The stirrer conforms to the bottom of the furnace and is bolted to the rockers so that it moves with the furnace as it is tilted.

Because of the extremely low frequency with the correspondingly low core loss, it was not necessary to use thin laminations for the magnetic circuit of the stirrer. Actually, the core is made from ¾ in. carbon steel plates, bolted together, while the teeth are made from angle iron welded to the core. The conductors are formed from a hollow rectangular copper section, and each coil consists

DANGER
HOT
SPOT

ONLY
ROCKBESTOS
AVA POWER CABLE
PROTECTS PRODUCTION
HERE

In Steel Mill and Foundry "hot spots" ordinary cable blisters, shrivels-up and quits quick. Only super-tough, permanently-insulated Rockbestos AVA (AVC) Power cable protects production here.

Rockbestos AVA (AVC) operates through temperatures up to 230° F . . . resists steam, grease or corrosive fumes . . . even withstands flames.

The Rockbestos "AVA (AVC) sandwich construction" special hi-dielectric tapes and felted asbestos . . . provide more years dependable service . . . cut maintenance and operating costs to the bone.

Stop "hot spot" wire failures and expense now—specify Rockbestos AVA (AVC) — the cable that *beats the heat.*

ROCKBESTOS PRODUCTS CORP.
NEW HAVEN 4, CONNECTICUT

NEW YORK • CLEVELAND • DETROIT
CHICAGO • PITTSBURGH • ST. LOUIS
LOS ANGELES • NEW ORLEANS
OAKLAND, CALIFORNIA • SEATTLE

This "sandwich" protects the varnish cambric. It enables AVA (AVC) to carry more current than cables with conventional insulations.

of several turns wound in pancake fashion and carefully formed to the required curvature.

Cooling of the stirrer winding is effected by circulating distilled water through the hollow copper conductors, and thence through water-to-water heat exchanger in a closed system. The coils of each phase of the 2-phase winding are all in series, electrically, but they are in parallel with respect to the cooling water circuit, so as to decrease the pressure drop to a reasonable value. This necessitates the use of a hose connection at each coil end and adjusting valves to balance the water flow.

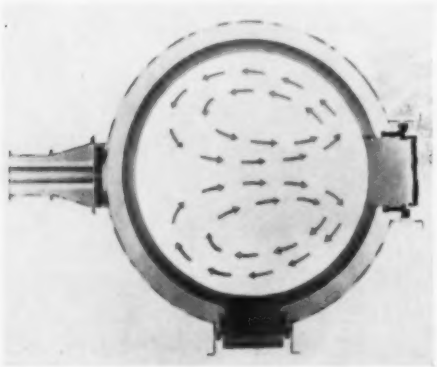


Figure 2 — Action of the induction stirrer induces movement of the molten steel as seen in this plan view.

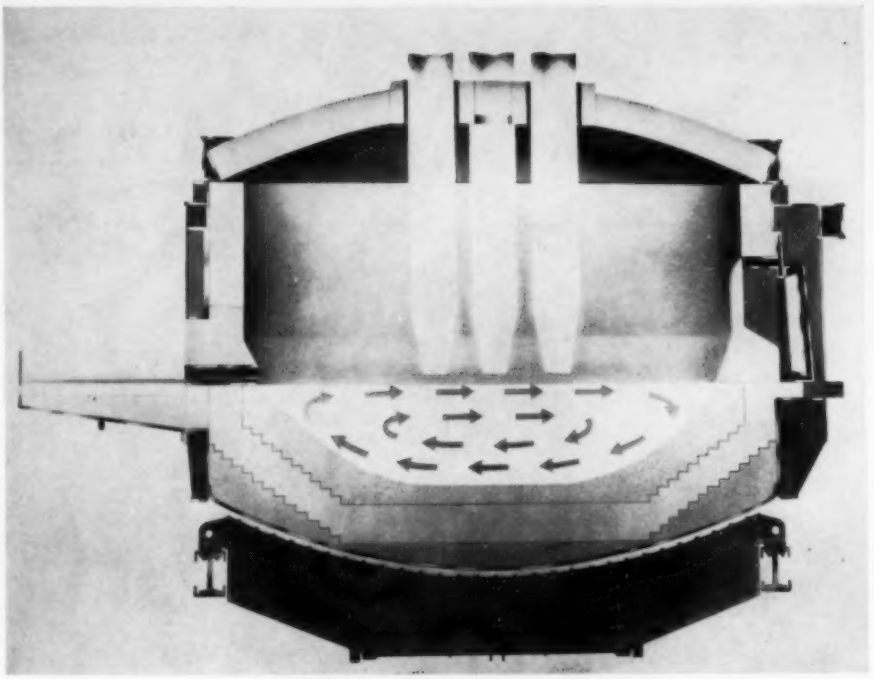


Figure 3 — Cross-section shows induction stirrer mounted on bottom of furnace. Stirring action can be directed as shown to facilitate slag removal, or in opposite direction during normal operation by reversal of magnetic field.

The winding is insulated with full Class B insulation, and is well braced to withstand the magnetic forces occurring in the end windings. Brass plates cover the inner surface of the stator as a protection to the slot portion of the coils, while stainless steel covers protect the end windings.

It is interesting to compare this device with the familiar induction motor. The distances from the "stator" surface to the molten metal, which becomes the "rotor," is about 30 in. Thus, we are dealing with a segment of a motor which has a 30-in. air gap. It is easy to understand why the power factor of the stirrer is not particularly high, being less than 50 per cent.

Currents induced in the molten metal, reacting with the magnetic field, set up mechanical forces which stir the entire mass, as seen in Figures 2 and 3. The theory of this action and an explanation of why this principle of stirring has advantages over all other possible methods has been covered elsewhere[4]. It may be pointed out that reversal of the direction of stirring, which is sometimes an advantage, may be accomplished easily by a reversal of the phase sequence in the generator.

The power for the stirrer is supplied by a 485-kva, 2-phase, 230-volt generator, driven by a synchronous motor, as shown in Figure 4. The generator is a commutator-type machine which obtains its excitation from a low-frequency commutator-type frequency-changer (Figure 5). The latter is a self-driven machine, which converts from 3-phase, 60-cycle power at its slip rings to 2-phase current of low frequency at its commutator, and furnishes sufficient power to excite the 2-phase field winding of the main generator. The frequency-changer exciter was built by ASEA, while the main generator, following ASEA ideas, was completely designed and built by the Elliott Co. at its Ridgway Division. The synchronous motor driving the special low-frequency generator is a conventional 3-phase, 60-cycle machine, having an 80 per cent leading power factor rating. To assure freedom from operating troubles caused by air-borne dirt, the motor-generator set has a closed ventilating system with an air-to-water heat exchanger.

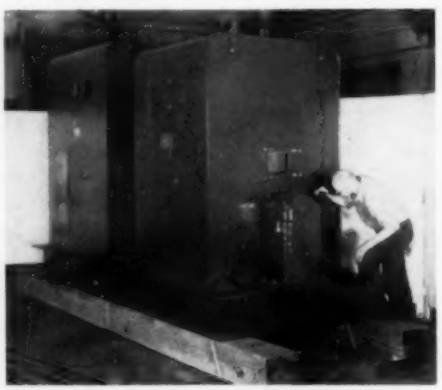
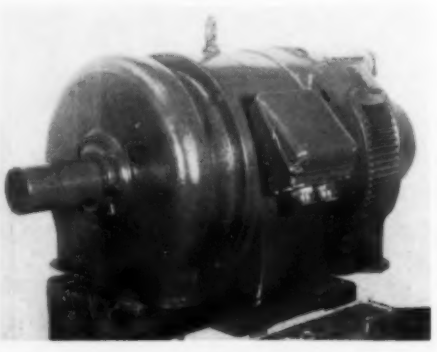


Figure 4 — A special motor-generator set serves as the main power supply to the induction stirrer. Conventional 60-cycle synchronous motor drives special low-frequency commutator-type two phase alternating current generator.

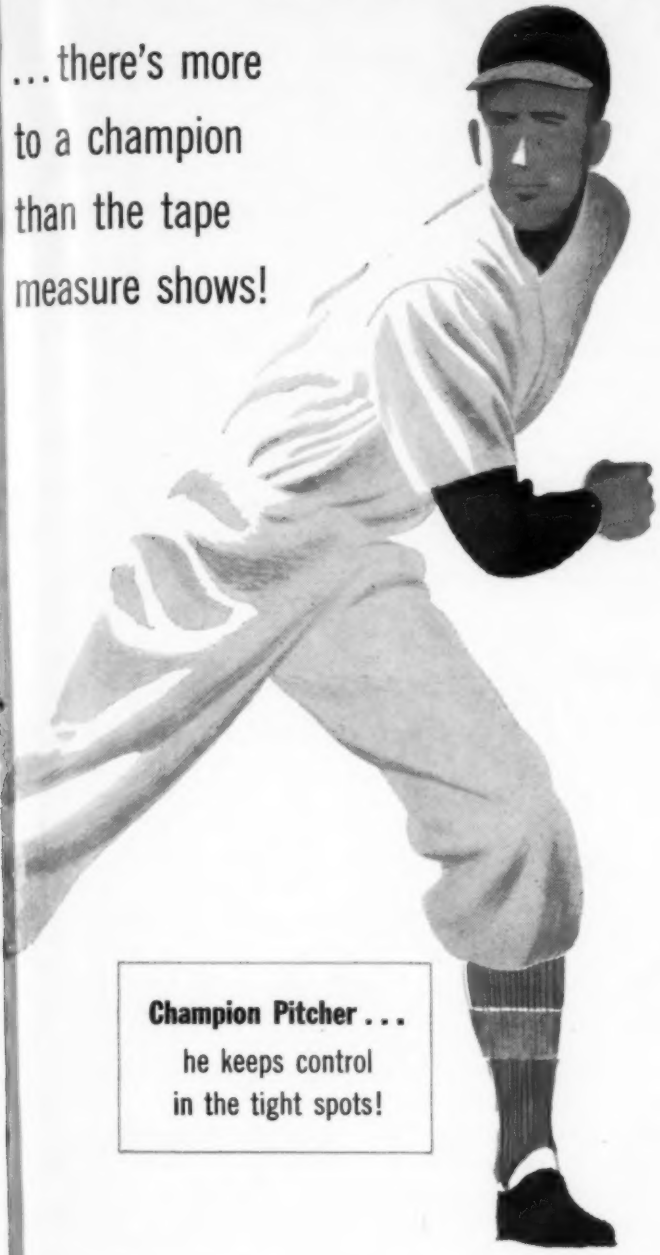
The stirrer equipment is centrally operated from a control cubicle mounted adjacent to the furnace control panel. The control equipment in-

Figure 5 — This special low-frequency commutator-type frequency and phase converter changer exciter provides excitation to the main power supply generator for the induction stirrer.

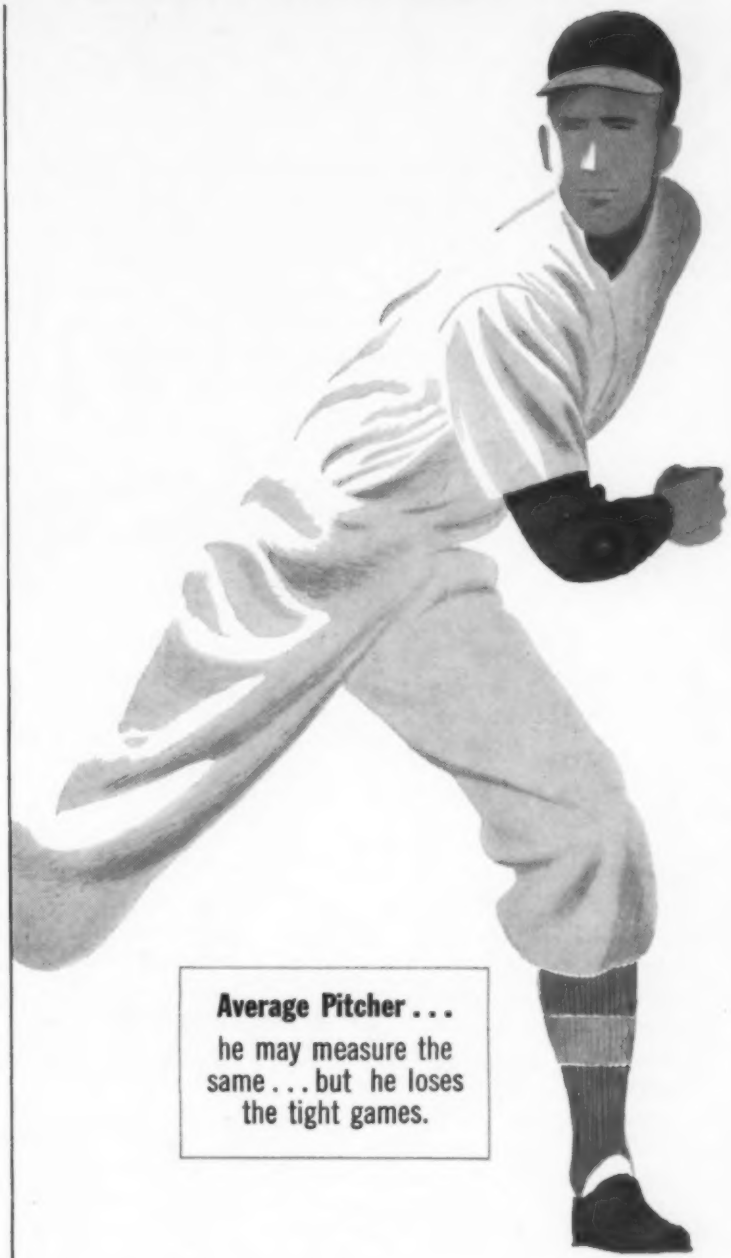


IT'S PERFORMANCE THAT COUNTS

...there's more to a champion than the tape measure shows!



Champion Pitcher . . .
he keeps control in the tight spots!



Average Pitcher . . .
he may measure the same . . . but he loses the tight games.

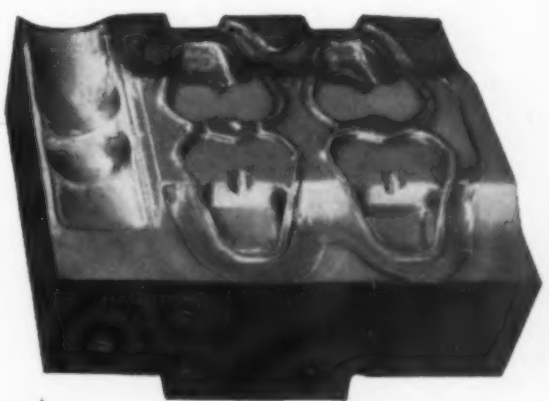
HARDTEM DIE BLOCKS

perform like "champions" in your production line!

Heppenstall Hardtem Die Blocks perform like "champions" because they possess those extras that result in superior quality. Their patented steel analysis resists softening and heat checking in service. Records from plants using Hardtem Die Blocks prove the following benefits for production:

- ★ **Long life of dies**
- ★ **Less down time**
- ★ **Lower overall die cost**
- ★ **Holding of true dimensions**
- ★ **Longer production runs**

It will pay you to try Hardtem Die Blocks. Call Heppenstall Company, Pittsburgh 1, Pa. Sales Offices in principal cities.



Heppenstall
. . . the most dependable name in die blocks

cludes a station for measuring, in 20 sections, the temperature of the furnace bottom above the stirrer, and an ASEA alarm system that will instantly warn the operators if abnormal temperatures should develop at any one of the measuring points.

Considerable interest in the Timken Co.'s stirrer is being shown among those responsible for the production of quality electric-furnace steel. This initial American installation establishes the ASEA induction stirrer as a new tool at the service of the U. S. steel industry.

BIBLIOGRAPHY

1. "*Induction Stirring in Electric Furnace Steelmaking*," by E. S. KOPECKI, Iron Age, September 22, 1949.

2. "*Metallurgical Aspects of Inductive Stirring in Arc Furnaces*," by S. Fornander, ASEA Journal, Volume 23, 1950.

3. "*Inductive Stirring in Arc Furnaces*," by SVEN FORNANDER and FOLKE NILSSON, Journal of Metals, Volume 188, Jan. 1950, and Volume 188, Feb. 1950.

4. "*An Induction Stirrer for Arc Furnaces*," by L. DREYFUS, ASEA Journal, Volume 23, 1950.

NEW BRITISH WHEEL PLANT SETS PRODUCTION RECORDS

▲ TAYLOR Bros. & Co., Ltd., who for many years have been the largest producers of railway wheels in the British Empire, recently put into production a completely new wheel forging and rolling plant at their works at Trafford Park.

The new plant produces wheels ranging from 24 to 50 in. diameter on tread, at a continuous rate of 60 pieces per hour. In conjunction with the consulting engineer, E. Homer Kendall, Kendall Engineering Co., Alliance, Ohio, the layout of the plant and the design of the equipment was completed by the engineering department of Taylor Bros & Co., Ltd., under the personal control of J. H. Ellis, assistant chief engineer in charge of development. The major items of plant comprise a 69-ft diameter rotary hearth furnace, an 8500-ton forging press, a 1,000-ton punching press, an electrically driven rolling mill, a 2000-ton dishing press and ancillary fully automatic handling plant specially designed to ensure fast production, together with an appreciable decrease in labor as compared with existing wheel plants.

Separate 6,600 volt incoming supply cables and switchgear have been installed and the plant has self-contained hydraulic, cooling water and compressed air services. With the object of reducing production delays and maintenance costs to a minimum, particular attention has been paid to the installation of single purpose equipment designed to give reliable service under conditions of continuous operation.

A distinctive feature of the new plant is the extensive use of special manipulating machinery fitted with individual oil hydraulic units. Economies in power have been effected by the use of air loaded accumulators in conjunction with the main hydraulic plant to regulate the operating pressure in accordance with the section being made.

METHOD OF MANUFACTURE

The blocks of steel from which the wheels are made are cut or broken from an octagonal or duodecagonal cross sectioned ingot of width from 12 5/16 to 18 in. across flats. The block weight is calculated from the finished wheel weight with appropriate allowances for furnace, punching and machining losses.

The blocks in the ingot breaking shop are taken by a gravity roller conveyor to a furnace charger in the main forge building. The charger picks them up individually and places them in radial rows on the hearth of the rotary furnace. The blocks pass successively through the preheating, heating and soaking zones in the furnace, and are then taken individually by a furnace discharging machine to a transfer car. This car transfers the block through a hydraulic descaling machine to the 8,500-ton hydraulic press.

After slabbing down between flattening tools the bloom is transferred to forging tools mounted on sliding tables on the bed and crosshead of the press. Under increased pressure the slab is forged to finish the hubs, partially form the bore and prepare a rim section suitable for rolling.

The complete forging is transferred from the dies to a live roller table by an unloading mechanism and is then conveyed to 1,000-ton capacity punching press of the upstroking type, equipped with hub clamping dies. The punched slug falls through

There is only one like this

There is only one Rust-Oleum

RUST-OLEUM®

STOPS RUST!

Specify Genuine Rust-Oleum
Accept No Substitute

The *exclusive* Rust-Oleum formula was developed by a Master Mariner during more than 20 years of combating the terrible rust-producing conditions of the sea. It incorporates a *specially-processed* fish oil vehicle that *dries*, is *odor-free*, and is formulated in *many colors*. It may be applied directly over *sound rusted surfaces* after scraping and wirebrushing to remove rust scale and loose particles. See why nearly every type of industry in the world has relied upon Rust-Oleum for over a *quarter century*. Clip the coupon to your letterhead and mail today.

RUST-OLEUM CORPORATION
2442 Oakton Street, Evanston, Illinois

Rust-Oleum Corporation
2442 Oakton Street, Evanston, Illinois

Gentlemen: I am interested in the *complete* Rust-Oleum story. Please send me the facts and the name of my nearest Rust-Oleum Industrial Distributor.

Name_____

Address_____

City_____ State_____

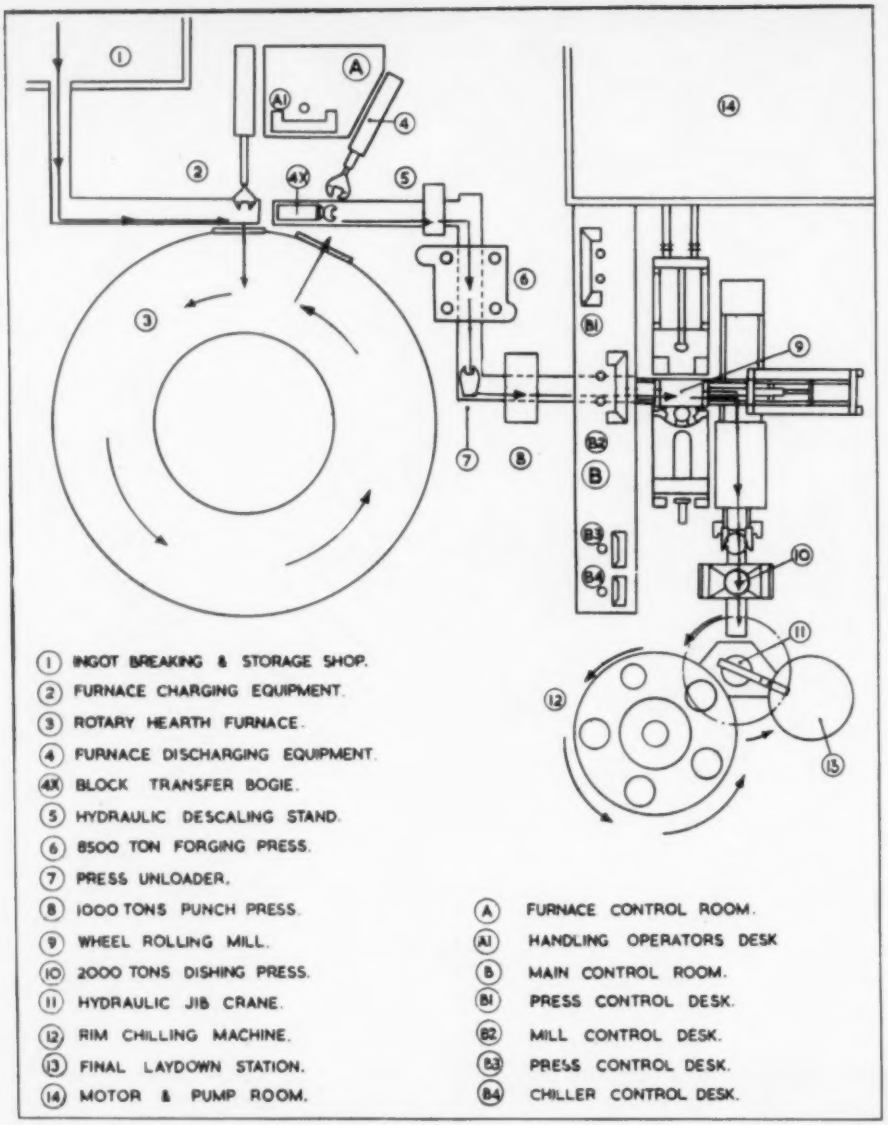

① INGOT BREAKING & STORAGE SHOP.
② FURNACE CHARGING EQUIPMENT.
③ ROTARY HEARTH FURNACE.
④ FURNACE DISCHARGING EQUIPMENT.
4X BLOCK TRANSFER BOGIE.
⑤ HYDRAULIC DESCALING STAND.
⑥ 8500 TON FORGING PRESS.
⑦ PRESS UNLOADER.
⑧ 1000 TONS PUNCH PRESS.
⑨ WHEEL ROLLING MILL.
⑩ 2000 TONS DISHING PRESS.
⑪ HYDRAULIC JIB CRANE.
⑫ RIM CHILLING MACHINE.
⑬ FINAL LAYDOWN STATION.
⑭ MOTOR & PUMP ROOM.
Ⓐ FURNACE CONTROL ROOM.
Ⓐ1 HANDLING OPERATORS DESK
Ⓑ MAIN CONTROL ROOM.
Ⓑ1 PRESS CONTROL DESK.
Ⓑ2 MILL CONTROL DESK.
Ⓑ3 PRESS CONTROL DESK.
Ⓑ4 CHILLER CONTROL DESK.

Figure 1 — Taylor Brothers & Co., Ltd. recently started a new wheel plant at their Trafford Park Steel Works, Manchester, England. View shows layout of plant.

a hole in the lower die to a quenching bin. The punched wheel then passes, on the roller table through a tunnel beneath the main control room to a position from which it is loaded into the rolling mill. In the mill, the rim section is reduced in volume and rolled to the required contours with an accompanying increase of wheel diameter. An unloading mechanism takes the rolled wheel from the mill and, by means of a transfer car, the almost completed wheel is carried to the 2,000-ton capacity dishing press. Suitably shaped dies clamp the wheel rim in the press and pressure applied to the hub and plate produces the correct hub offset and plate contour. Finally, after dishing, the wheel is stamped with identification numbers and transferred either to a five station rim chilling machine or direct to a cooling bed.

THE CHARGING MACHINE

The furnace charging machine consists of a cable driven carriage mounted on a fixed but adjustable bridge. The peel hoisting mechanism and the oil hydraulic equipment for the gripping motion are mounted on the carriage. The peel structure is pivoted at the rear and is fitted with forging manipulator type sheaves at the furnace end. Mounted on the peel structure is the peel proper equipped with special tongs which have been designed to ensure accurate spacing of the blocks on the hearth and to permit a straight withdrawal from the furnace. Rotation of the peel through an arc of 90 degrees is effected by means of cams and rollers which are operated by the action of hoisting or lowering the peel structure.

The machine is arranged automatically to complete a cycle of operations initiated by the operator after he has indexed the rotary hearth of the furnace. With the tong head resting on a centering cam and the block lying on the roller conveyor against the conveyor and the stop, the cycle commences with the lifting of the furnace charging door. The tongs grip the block at a fixed distance from its base. The peel structure is lifted and the tongs rotate 90 degrees to bring the axis of the block into the vertical position and the base of the block to a fixed distance above the furnace hearth level. The carriage moves to the extreme forward position in order to bring the first block to the innermost position on the furnace hearth. Completion of forward travel actuates first the lowering of the block to the hearth which motion, in turn, release the grips. At the end of the release stroke the carriage moves back to its original position and lowers the peel structure until the tong head again rests on the centering cam. The cycle is then repeated and a second bloom is charged. The forward travel of the carriage is sequence controlled from a multiple cam limit switch of the vernier setting type. After the seventh or outside bloom has been charged, the furnace door is closed and the peel and

Figure 2 — The 69-ft rotary hearth furnace has a rated capacity of 40 long tons of steel per hr.

tong head cooling sprays are brought into action. The carriage travel control has provision for variable radial spacing of the blocks on the furnace hearth and for the charging of any number up to a maximum of seven blocks.

THE FURNACE

The furnace, built by the Salem Engineering Co. Ltd., is the largest

bright annealing

OF STAINLESS STEEL TUBING at 2050°F

THESE ARE THE TWINS

The combination of the Drever TUBE TYPE BRIGHT ANNEALING FURNACE with extended water jacketed cooling chamber, and the Drever AMMONIA DISSOCIATOR provides the right way to BRIGHT ANNEAL STAINLESS STEEL AND INCONEL TUBING.

Let our experience help solve your problems. Write or 'phone

DREVER CO.

730 E. VENANGO STREET • PHILADELPHIA 34, PA.

...here are the facts:

1—Fully Annealed
2—Absolutely Bright
3—No scale, oxides or scratches
4—No Carbide Precipitation
5—No pickling required before drawing
6—No pickling after finish anneal
7—Furnace can be gas or electrically heated
8—Capacities up to 2000 lbs./hour
9—Tubing from capillary size to 2½" O.D.

6

of its kind in the country. It has a rated heating capacity of 40 tons of steel an hour at a maximum temperature of 1280 C. The diameter over the outer buckstays is 69 ft 0 in. The hearth is 15 ft 0 in. wide and has a mean diameter of 48 ft 3 in. The charging and discharging doors are set at an angle of 30 degrees and there are 2 suspended baffle walls between the doors and built radially across the furnace. Small doors in the inner and outer walls between the baffle walls facilitate cleaning of the furnace hearth while the furnace is in operation. The furnace has four firing zones and is fitted with 39 steam atomizing burners designed for heavy fuel oil burning. Preheated air for combustion is obtained by utilizing part of the heat contained in the waste gases—two Newton Chambers needle type metallic recuperators being used as heat exchangers. Preheated air is used in the heating zones and atmospheric cold air in the preheating and soaking zones. The hearth, which is of the Salem floating type, is driven at diametrically opposed points by a 27-hp motor coupled through a differential gear and line shafting arranged in the furnace foundation. There is a 200/1 reduction worm gear driven by V-ropes at each end of the shafting. A pinion on the worm gear output extension shaft engages a rack mounted under the rotary hearth structure.

The hearth is carried on 108 wheels fitted with taper roller bearings running on circular rails. Fifty-three rows of blocks are arranged in the 330 degrees between the charging and discharging doors giving a maximum of 371 blocks in the furnace at any one time. The rows of blocks are carried through the heating and soaking zones of the furnace by progressive indexing of the hearth at a rate corresponding to the output of the plant. At a production rate of 60 pieces per hour the heating time of the blocks is approximately 6¼ hours. The furnace is equipped with Honeywell Brown "Electronik" temperature controllers and Electroflo fuel/air ratio controls on each zone and with Electroflo automatic furnace pressure control operating on the recuperator dampers.

The roof is of the flat suspended arch type and is formed of tongued and grooved interlocking blocks. The tongues and grooves are tapered in two directions. The larger blocks connect with the supporting structure by means of mild steel hangers and clips—the hangers having toggle joints which by hinge effect give maximum movement in all directions to correct for expansion and contraction.

The furnace walls are carried on the sand seal dipper castings. The inner wall forms a polygon of flat vertical panels and is made of tongued and grooved interlocking bricks. A four piece refractory burner is placed in the center of each panel. The vertical joints at the junctions of the panels are made of dovetailed blocks which are anchored to the inner buckstays by means of alloy bolts to prevent outward movement due to expansion.

FURNACE DISCHARGING MACHINE

The heated blocks are removed from the furnace by a high bridge type discharging machine of one-ton capacity. The machine is of a similar basic design to the charging machine —having a cable driven carriage in which is mounted a rocking peel structure. The hoisting of the peel of the discharging machine, intended merely to clear the hearth, is effected by means of eccentrics mounted on extension shafts of a worm reduction gear coupled to a 27-hp-dc motor. The grips are operated by a Vickers-Detroit combination pump—the small volume portion being used to maintain the grip while the large volume pump is unloaded to tank. The grip cylinder is controlled by means of a solenoid pilot operated, sub-plate mounted 4-way valve of the latest design. The carriage a welded box type structure, forms the oil tanks for the gripping gear. Travel of the carriage to the predetermined billet position is controlled by a multiple cam type limit switch with vernier setting ajustment and "slow down" and "stop" rings for each billet position. The grips, at the withdrawn position, are aligned over an air operated ram which has a stroke of 30 in. Operation of the elevator ram is interlocked with the discharger carriage in order to prevent the release of the block when the elevator is not at the top of its stroke while permitting the operator to commence the discharging cycle before the elevator is raised. To commence the discharge of a row of blocks, the carriage travels to the outermost hearth position with the peel lowered. Completion of travel initiates gripping which is followed by a hoisting of the peel, withdrawal to the elevator and a lowering of the peel. If the elevator is raised, the release of the grips and subsequent lowering of the elevator take place automatically together with a closing of the furnace door. The operator then initiates transfer of the block to the descaler and press and the discharging machine may be restarted. This, after the furnace door has been rehoisted, commences its inward travel again and completes its cycle by withdrawing and holding a second block over the elevator until the latter is automatically raised following the return of the transfer car to the furnace. The cycles are repeated until the innermost block in a radial row has been discharged. A system of signal lamps on the control desk shows the operator at a glance how many blocks remain to be charged and discharged at any time. The hearth is not indexed until a clear space is indicated at the discharging position. Complete sequence controls on each machine automatically reset for the next cycle of operations. A rotating dial mounted outside the control room is geared to the hearth and is used for maintaining continuous indications of the progress of the blocks through the furnace and

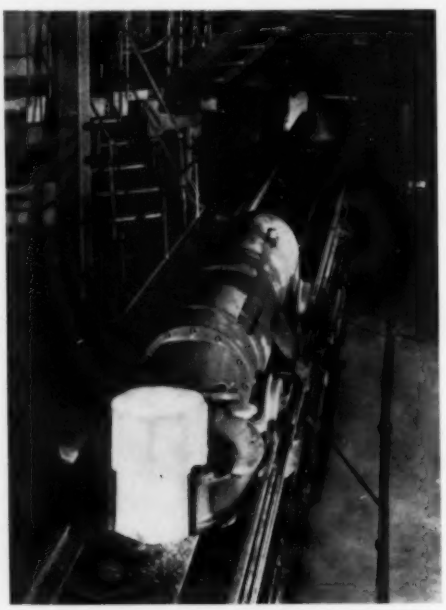


Figure 3 — The transfer buggy is shown taking the billet from the furnace discharge to the 8500-long ton capacity forge.

A HE-MAN CRANE FOR A HE-MAN SHOP!

One machine tool primer defines a forge shop as "a place for a real he-man who can stand up and take it."

That overhead electric traveling crane—which must always be ready and able—must also have he-man ruggedness and dependability

Moving swiftly back and forth—from furnace to forging press—this 25-ton NORTHERN CRANE swings hot billets, too hot and too heavy to handle in any other way.

This is one of the many NORTHERN CRANES installed in the last 54 years to assure the most efficient production from machine tools and other machinery.

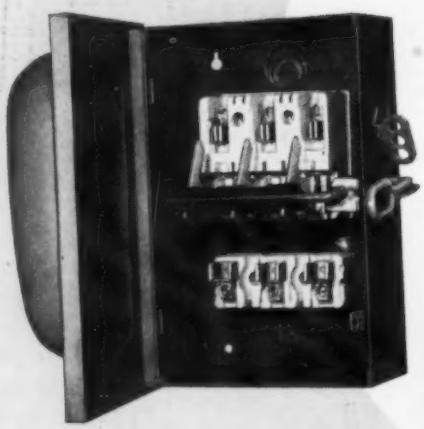
USE NORTHERN CRANES

NORTHERN ENGINEERING WORKS

2615 ATWATER STREET, DETROIT 7, MICHIGAN

BUILDERS OF CRANES AND HOISTS EXCLUSIVELY

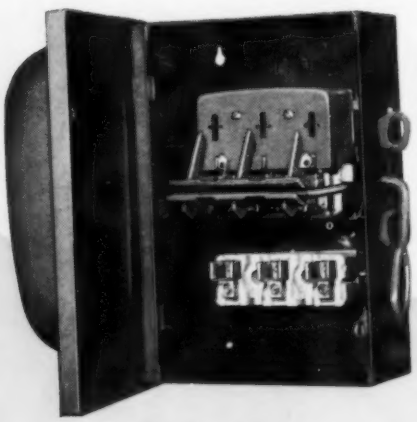
3 LINES OF SAFETY SWITCHES *for* 3 DIFFERENT MARKETS



. . . one line can't do two or three jobs without compromising price and performance!

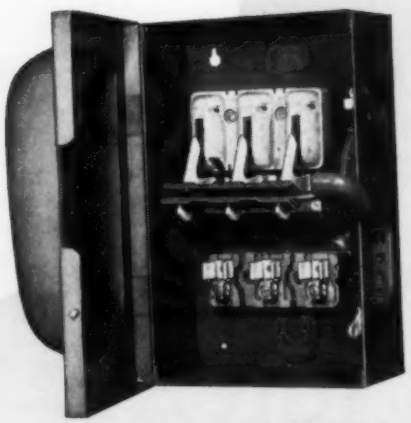
GENERAL PURPOSE

90,000 line designed for residential, commercial and other applications where price is limiting and the service factor is not great.



INDUSTRIAL

40,000 line designed for general industrial or institutional and commercial applications where the service factor is greater and price is an important consideration. MEETS BOTH GOVERNMENT AND NEMA SPECIFICATIONS FOR TYPE A SWITCHES.



HEAVY-DUTY INDUSTRIAL

80,000 and 50,000 line designed for mass production industries where price is secondary to continued performance under conditions of severe service and maximum safety. The 50,000 line is used where space is limited. BOTH ARE TYPE A but go far beyond those requirements.

UNIFORM STYLING

ASK YOUR ELECTRICAL DISTRIBUTOR FOR SQUARE D PRODUCTS

SQUARE D COMPANY

Figure 4 — Canal water is used for descaling at a pressure of 1500 psi. Transfer car turns the water on-and-off automatically.

of the operation of the hearth indexing limit switches.

THE TRANSFER CAR

A tubular fabrication mounted on four flanged wheels forms the body of the transfer car. The front bulkhead of the body carries the grips. The car travels on flat bottom rails on a fabricated track structure 67 ft 2 in. long of which one end is built into the hydraulic descaler. An electrical contact switch at the furnace end of the track is automatically operated by the transfer car to control the supply of cooling water to the peel of the discharging machine. Similar track switches at the press end of the track are used for slowing down the car prior to it entering the descaler, for operating the descaler control valve and for finally stopping the car when the block is over the 8,500-ton press slabbing die.

THE HYDRAULIC DESCALING MACHINE

This machine has six Harland-Aldrich No. 2 nozzles each of 27.2 gpm capacity mounted in an adjustable header pipe above the block and six similar nozzles in a fixed header pipe arranged 6-in. below the lower surface of the block. Canal water is used for descaling at a pressure of 1,500 psi. Supply to the nozzles is controlled by a Hunt "Quick-as-Wink" air operated valve and the system is fitted with a priming pipe and non-return valve to maintain water in the nozzle headers and to eliminate hydraulic shock. Descaling is fully automatic—the transfer car turning the water on and off on its forward travel to the forging press.

8500-TON PRESS

The block is slabbed down on the forging press between flat dies until the required thickness is obtained, gripped in the centering arms and transferred to the lower forging die.

The upper sliding table is then moved to bring the top forging die under the center line of the press. The second forging operation is completed under intensified pressure and during this process the next block to be forged is placed on the slabbing die. The lower sliding table is moved back to bring the completed forging over the stripping ram and the following block under the press crosshead.

At 5,600 psi intensified pressure the maximum load on the press is 8,500 tons. This load can be reduced on smaller forgings by reducing the pressure in the air loaded accumulators.

The press is fitted with four cylinders, having a diameter of 33⅜ in. and a stroke of 36 in. The daylight between the sliding tables is 5 ft 7 in. The top and bottom tables have travels of 5 ft 0 in. and 9 ft 6 in. respectively.

Figure 5 — Wheel is shown after forging just before transfer to the punching press.

The columns are at 8 ft 0 in. centers and have a minimum diameter of 26 in. The crosshead is a one-piece steel casting designed to transmit the load from the four rams which are located between the columns to the center of the crosshead. Built into the crosshead are twin hydraulic cylinders for moving the top sliding table.

The hydraulic intensifier, which has a ratio of 2.87/1, gives a pressing stroke of 6 in. The press is equipped with a large prefill tank and surge tank.

Figure 6 — The 1000-long ton capacity punching press is of the up-stroke type.

The roller table is divided into four units each having a separate driving motor. No. 1 section serves as a receiving table from the press unloader. No. 2 section is built into the punching press and mounted on the press column structure. No. 3 and 4 tables carry the blank from the punching press under the main control room into position for charging into the mill. Tables 1, 2 and 3 are driven by 10-hp, a-c motors running at 965 rpm giving a surface speed of 192.5 fpm. These tables run continuously. No. 4 table is driven by a 5-hp, d-c motor which gives a table speed of 99 fpm. This table is slowed down and stopped by photocell equipment at the mill end and is restarted automatically by operation of the mill loading mechanism.

The punching press is of the upstroking type equipped with twin 26-in. diameter rams and with double acting pull back cylinders. The press has a rated capacity of 1,000 tons and a punching stroke of 9½-in. at a speed of 3 in. per second. A 100 ton capacity boss clamping cylinder is mounted in the press crown around a rigid punch stem. Jack cylinders give an approach speed of 6 in. per second. The forging, on arrival in the punching press, is centered by an adjust-

Figure 7 — Edge rolls of mill reduce the rim section area. At same time the pressure rolls on the wheel tread form the flange.

able stop mechanism and lifted off the live rollers by the lower boss clamping die. Continued upward movement of the crosshead first clamps the boss and presses the hub against the rigid punch. When the punch has completely penetrated the boss, the crosshead is stopped by limit switch control and the forging is then lowered on to the live rollers. In the meantime the centering stop is removed and the forging is allowed to proceed to the mill. The control gear is similar to that used on the 8,500 ton press.

The forged rim section is reduced in area in the mill and formed to the required shape by means of driven edging rolls which bear on the front and back faces and on the inside contours of the rim, and by the load on two pressure rolls which bear on the tread and form the flange. The mill, which is of Taylor-Kendall design, has also a driven main roll mounted in an adjustable carriage and two guide rolls mounted on a separate carriage, but sliding on the same ways as the main carriage. The hydraulic pistons for the guide roll carriages are attached to the main roll carriage to give movements relative to that carriage. The mounting arrangement of the guide rolls permits their retraction behind the main roll to facilitate loading and unloading of the mill. The arrangement adopted reduces the handling time at the mill and simplifies the handling equipment. Pressure regulation on the carriages during rolling controls the formation of the section and the rate of expansion of the wheel diameter. Indicating equipment is built into the mill to show the inside diameter of the rim, and mill setting scales are mounted on the side of the main stand for rapid setting-up to suit varying rim width and roll diameters.

The top and bottom edging rolls are each driven by a 400-hp, d-c motor having a speed range of 690 to 860 rpm. These motors during rolling are coupled in series across a 480-volt generator. The motors drive through a primary reduction gear of 38/136 ratio and wobbler shafts which are coupled horizontally to 20-tooth, 1.4148 D.P. spiral bevel pinions engaging 27-tooth wheels mounted on the roll shafts. The edging roll shafts are inclined at 35 degrees to the horizontal plane and are mounted in quill castings which also form the bevel gear casings. At the roll end of the shafts are 4-row Timken "balanced proportion" type roll neck bearings. Steep angle taper roller bearings are mounted in a cartridge behind the bevel gears. The input bevels are mounted in the quills on stub shafts carried in cartridge mounted taper roller bearings. The main roll, which is the only other driven roll, is carried on a tapered extension of a vertical shaft mounted on a Timken 2-row "balanced proportion" roll neck bearing with a double row taper roller bearing at its lower end. A single helical gear wheel is mounted on the roll shaft and engages a pinion on a vertical intermediate shaft which also carries a spiral bevel wheel. A bevel pinion is mounted horizontally on a shaft coupled to a 150-hp mill motor having a speed range of 460 to 1150 rpm. This motor is fed from a separate generator mounted on the main set and has a "shovel" characteristic to prevent it taking load from the edging roll drive motors and overloading itself. All driven roll speeds are independently variable, and the overall mill speed is also adjustable to maintain pre-set roll speed ratios modified to suit the various roll diameters.

The wheel, on completion of the rolling, is transferred to a flat topped car by an unloading mechanism similar in design to the one used for loading the mill. The car, which is cable driven, takes the rolled wheel over the bottom die of the dishing press. A swinging arm is brought into position by the dishing press operator who then returns the car to the mill end of its track. The car in returning slides from underneath the wheel which is restrained by the stops and the wheel falls on to the die. The lower sliding table of the press is then moved bringing the die under the crosshead ready for the next forging operation.

The dishing operation changes the web of the wheel from a flat disc to a cone shape and sets the boss offsets. The press has a rated capacity of 2,000 tons at an accumulator pressure of 2,200 psi intensified to 6,000 psi on a single ram 31⅝-in diameter by 2 ft 7 in. stroke.

RIM CHILLING MACHINE

This machine consists of five chilling stations mounted on an electrically driven turntable 14 ft 0 in. diameter. At each chilling station is placed a set of three tapered rolls one of which is driven by an electric motor mounted inside the turntable hood. Box section spray rings are mounted on the roll housings and coupled to a pump located inside the turntable hood through a solenoid operated valve. This pump, rotating with the table structure, draws water from an annular tank located around the vertical post which carries the weight of the whole machine.

How to save $ $ $ $ per hour!

The cost of "DOWN TIME" on steel mill processing lines can be counted in $$$$$. This includes the "Backup" of supply at the entry end, and shortage of finished material at the exit end.

It could cost $$$$$ too, in other types of continuous production lines, such as automotive, and in the huge multi-motored machines which perform a series of operations automatically.

To prevent lost time, lost production, and lost labor, electrical control apparatus must operate dependably, and with minimum maintenance. CLARK has specialized for over 25 years in the development and manufacture of dependable heavy duty control.

Various individual CLARK contactors, relays, timing devices, magnetic amplifiers, and other control devices have been combined on panels to provide the acme of dependable, trouble free service, in all types of industry.

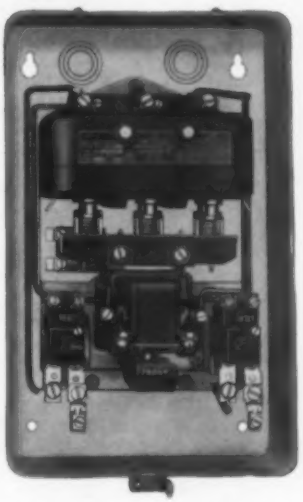
Bulletin 7313 Type VT Vari-Time Relay
Bulletin 7311 Type P Plugging Relay
Bulletin 7400 Type RT Vari-Time Contactor
Bulletin 7328 Form LT Overload Relay Automatic Reset Type

CLARK Vari-Time Contactors and Relays have an hermetically sealed, built-in core that delays for a definite pre-set time—up to and including 6 seconds—the closing of the main contacts after the coil is energized. This combination eliminates one timing relay for each accelerating step, simplifies wiring, and reduces maintenance.

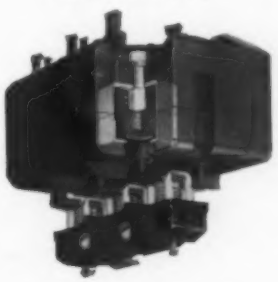
CLARK DC magnetic overload Relays with "sealed-in" mechanism provide both inverse time limit and instantaneous protection.

CLARK Plugging Relays feature "fail-safe" and tamper-proof operation with rugged simplicity of design, thus affording maximum electrical and mechanical protection to the equipment.

For A. C. operation CLARK Type "CY" Starters and contactors in Sizes 2 and 3 feature an entirely new and successful arc quenching principle. Sizes 0 and 1 are also built for heavy duty applications. Combined with relays and other CLARK AC apparatus, they function ideally on multi-motored, diversified operation machines, as well as on individual motors.



Phantom view of Arc Shield in Type "CY" Starter



Bulletin 6013 Type "CY" AC Magnetic Starter, cover removed

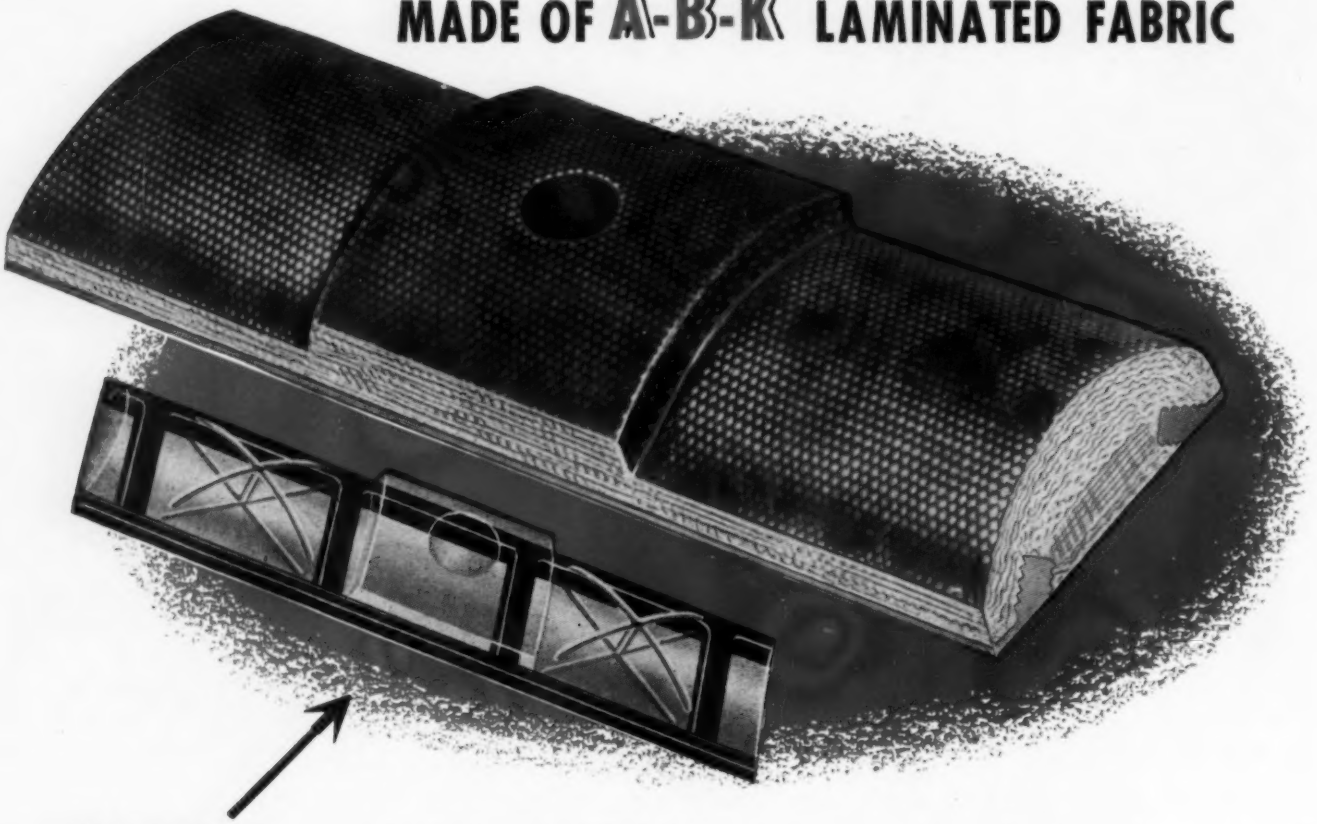
To save costly "DOWN-TIME" specify and use Clark engineered electrical control

THE CLARK CONTROLLER CO.

ENGINEERED ELECTRICAL CONTROL • 1146 EAST 152ND STREET, CLEVELAND 10, OHIO

NOW . . . a *reinforced* slipper bearing

MADE OF A-B-K LAMINATED FABRIC



THE SECRET IS THIS LADDER

This manganese-bronze "ladder", molded in tough A-B-K Fabric, makes a reinforced bearing remarkable for its strength, durability and long life.

A-B-K MATERIAL . . . uniquely reinforced . . . gives remarkable bearing life, exceptional coupling protection

If your present slipper bearings break, wear excessively or need constant maintenance, change to this new A-B-K Bearing.

Made of A-B-K Laminated Fabric, it eliminates metal-to-metal contact. It protects coupling members, will not peen out or take a permanent set. The interlocking, reinforcing "ladder" enables it to withstand exceptionally severe shock loads and strains without splitting or breaking apart. Result: down time is reduced, tonnage is maintained, replacement and maintenance costs are minimized.

Investigate this new A-B-K Reinforced Slipper Bearing. Our engineers will be glad to recommend the right material formula for your specific use.

A-B-K Material Has Many Unusual Properties . . . exceptionally low coefficient of friction . . . highly resistant to shocks and strains . . . excellent structural strength . . . wears slowly and evenly . . . will not score or heat check metal parts . . . good dielectric qualities . . . can be machined to close tolerances . . . grease or water lubricated . . . available in eight different formulas.

If these characteristics suggest a use to you, either as a bearing or for some other component part, A-B-K Engineers will be glad to work with you in its development. Write for our free explanatory folder, today.

A PRODUCT OF

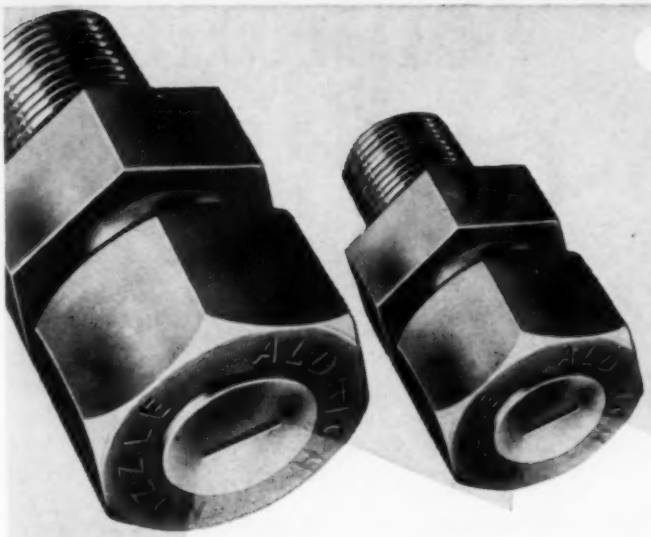
AMERICAN Brake Shoe COMPANY

Copyright 1952 — American Brake Shoe Co.

AMERICAN BRAKEBLOK DIVISION

DETROIT 9, MICHIGAN

IN CANADA: JOSEPH ROBB & CO. LTD., MONTREAL, QUEBEC



Why ALDRICH Nozzles Give You EFFECTIVE DdescaLING

1. The sharp, knife-like jet of water and the solid striking force developed by Aldrich Patented Descaling Nozzles give far more effective descaling than nozzles which produce jets of equal force but with a larger impinging area. This has been proved in hot strip as well as billet descaling.

2. By use of Venturi tube design and a rectangular orifice, Aldrich Nozzles produce a cutting spray with an impinging force equal to 95% of the potential energy supplied to the orifice—resulting in thorough descaling without causing excessive cooling due to over-abundant use of water.

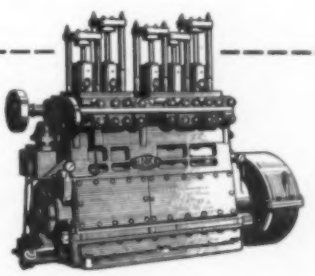
3. Should clogging occur, Aldrich design permits easy cleaning of the orifice disc. When replacement becomes necessary, you need only insert a new disc—NOT AN ENTIRE NEW NOZZLE.

4. Aldrich orifice discs have a 1/32" bevel on the inside circle—preventing too sudden choking of water when it reaches the disc—also preventing undue wear and friction loss.

5. Aldrich discs are capable of withstanding high pressures for long periods of time. They are made of hardened stainless steel, machine ground to uniform contour, then profiled and burnished to a polished finish. This removes the slightest imperfection on the orifice—preventing streaking on the surface of metal being descaled. Every Aldrich disc is hydraulically tested for uniform pattern and force.

6. Whether used for hydraulic descaling of billets, sheets, plates, or small parts—Aldrich Nozzles insure rapid and thorough descaling; prevent excessive cooling; increase roll and pass life; reduce damage to forging dies; reduce delays due to grinding or changing guides, and afford longer service per insert disc.

Several types of Aldrich Descaling Nozzles are available from stock. May we send you complete information? Data Sheet 61-2 is available on request.



Aldrich Direct Flow Pumps used for descaling systems are fitted with automatic by-pass valves which operate with all types of accumulators. Both descaling cabinets and hydraulic systems, for shell forgings and other small to medium forgings, have been designed by Aldrich. Write for literature or recommendations.

THE ALDRICH PUMP COMPANY

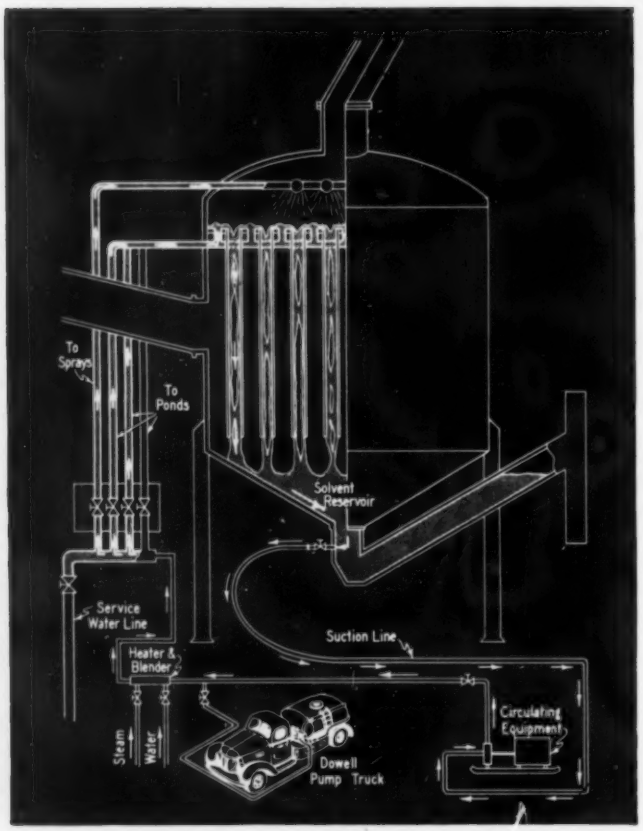
21 PINE STREET • ALLENTOWN, PENNSYLVANIA

...Originators of the Direct Flow Pump

Representatives: Birmingham • Bolivar, N. Y. • Boston • Buffalo • Chicago • Cincinnati • Cleveland • Denver • Detroit
Duluth • Houston • Jacksonville • Los Angeles • New York • Omaha • Philadelphia • Pittsburgh • Portland, Ore.
Richmond, Va. • St. Louis • San Francisco • Seattle • Spokane, Wash. • Syracuse • Tulsa • Export Dept.: 751 Drexel Building, Phila. 6, Pa.

Electrostatic Precipitators Cleaned in Just 12 Hours

Dowell Service Saved 178 Hours of Downtime by Cleaning with Chemicals



A diagramatic sketch showing hook-up for cleaning precipitators. Dowell Service engineers bring all necessary chemicals, pumps and other equipment right to the job.

Saving downtime is more important than ever. That's why Dowell Service is specified for maintenance cleaning by an ever-increasing number of companies.

One steel company had a series of precipitators with the usual collection of caked dust and corrosion products. To clean by reaming and scraping would have taken an estimated 190 hours. Dowell Service removed the deposits by flooding weirs and ponds with specially prepared solvents. *The job was completed in just 12 hours!*

An unusual case? Not at all! A check list of steel mill equipment reveals 50 different pieces of equipment that have been cleaned chemically by Dowell Service.

Free Bulletin on Chemical Cleaning for Steel Mill Equipment

Send today for this informative bulletin on steel mill maintenance cleaning. Contains descriptive case histories plus handy check list of equipment cleaned by Dowell. Write to Dept. C-29 Tulsa, Oklahoma.

Dowell Service

Over 90 Offices to Serve You with Maintenance Cleaning for:

Boilers • Condensers • Heat Exchangers • Gas Mains
Stoves • Furnace Cooling Systems • Piping Systems • Gas Washers • Process Towers • Ammonia Scrubbers • Precipitators

Chemical Services for Oil, Gas and Water Wells

DOWELL INCORPORATED
Tulsa 1, Oklahoma

DOWELL

A Service Subsidiary of
THE DOW CHEMICAL COMPANY

Date-line Diary...

January 3

▲ The Labor and Commerce Department reported that construction expenditures rose to $32,300,000,000 in 1952, a new high. Of this, approximately $21,800,000,000 was spent for private projects, and $10,500,000,000 for public construction.

▲ The price of zinc rose ½¢ to 13¢ a lb in East St. Louis.

▲ According to the AAR, rail freight loadings declined to 37,900,000 cars in 1952, or 6.2 per cent less than 1951.

January 5

▲ Based on reports from companies having 93 per cent capacity of the steel industry, the operating rate for the week beginning January 5, 1953 is scheduled at 98.2 per cent of capacity. This is equivalent to 2,213,000 tons of ingots and castings compared with 2,226,000 tons one week ago.

▲ In a semi-annual report covering the first six months of 1952, the CIO United Steelworkers net worth was listed at $10,394,600. Its membership increased 32,000 to 1,100,000, a record high.

January 6

▲ In 1952 United States steelmaking capacity reached a new high of 117,500,000 tons, or an increase of 8,900,000 tons in 1952.

▲ The Atomic Energy Commission awarded Blaw-Knox Co. a $40,000,000 contract for construction of a chemical plant at its Hanford Works in Richland, Wash.

▲ Automotive News reported that industry-wide auto production totaled 4,336,477 units in 1952, or 18.6 per cent less than 1951.

January 7

▲ For the fiscal year ending October 25, 1952, Lukens Steel Co. reported net income after taxes of $2,316,791. This is equivalent to $7.29 a share on capital stock. Sales for 1952 totaled $69,616,358.

▲ A guaranteed annual 3 per cent wage boost, or 6¢ an hr was demanded by railroad unions, on the basis of increased productivity, at a government sponsored public hearing in New York.

▲ The Berger Manufacturing Division of Republic Steel Corp. at Canton, Ohio will be the fabricators for Republic's new venture of manufacturing steel kitchens. The cost of retooling this plant was $1,000,000.

▲ According to the Aluminum Association, production of primary aluminum in November, 1952 totaled 149,277,906 lb compared with production of 144,491,926 lb in November 1951. Shipments of aluminum sheet and plate were 96,706,462 lb for the month compared with 78,178,185 lb in November 1951.

January 8

▲ For the first quarter of 1953, Mystic Iron Works of Everett, Mass. increased pig iron prices 25¢ a ton. No. 2 foundry iron is listed now at $59.50 and malleable iron at $60.00 per gross ton.

The price of lead was reduced ¼¢ a lb to 14½¢ a lb in New York.

▲ Colorado Fuel & Iron Corp. completed the purchase of John A. Roebling's Sons Co. of Trenton, N. J.

▲ The Defense Materials Procurement Agency announced a loan of $67,500,000 by the Export-Import Bank to finance the development of more high-grade manganese ore from deposits in Brazil for the U. S.

January 9

▲ Steel production in Canada for 1952 reached a record high of 3,720,000 tons.

January 10

▲ Seven nickel distributors in the United States were authorized by the OPS to increase price of nickel 3½¢ a lb, after the Canadian Government approved International Nickel Co.'s similar request.

January 12

▲ An additional $5,000,000 loan authorized under the Defense Production Act has been approved by the RFC for Lone Star Steel Co. at Dallas, Texas. This loan will be used for equipment and spare parts, and to cover increased costs in building its steel plant.

▲ According to the SEC and FTC, net profits of manufacturing corporations in the third quarter of 1952 totaled $2,600,000,000.

▲ Based on reports on companies having 93 per cent capacity of the steel industry, the operating rate for the week beginning January 12, 1953 is scheduled to be 99.4 per cent of capacity. This is equivalent to 2,240,000 tons of steel ingots and castings compared with 2,213,000 tons one week ago.

January 13

▲ The price of lead dropped ½¢ to 14¢ a lb in New York.

▲ The ARCI announced that deliveries of new domestic freight cars in December totaled 7845 compared with 5929 in November. Deliveries for 1952 were 77,768 cars. New orders in December totaled 1159 cars, and the backlog of cars on order as of January 1 was 80,296.

▲ The United Nations Economic Commission for Europe reported that Europe's total steel production in 1952 was estimated at 109,000,000 metric tons, or a 10,000,000 ton increase over 1951.

January 14

▲ United States Steel Corp.'s No. 4 blast furnace at the Ohio Works will be down three weeks for repairs.

▲ Promissory notes in the amount of $140,000,000 were sold by Bethlehem Steel Co. to Guaranty Trust Co.

▲ According to the Bureau of Mines, consumption of scrap and pig iron during October totaled 12,068,411 gr tons.

▲ A national underwriting group offered 130,758 shares of $1.00 par value common stock on behalf of Hagan Corp., which is the first public offering of stock by the company.

January 17

▲ The F. W. Dodge Corp. announced that construction contract awards in 1952 for the thirty-seven states east of the Rockies totaled $16,774,936,000, or 6 per cent greater than 1951. Construction awards in December were $1,467,384,000, or 19 per cent more than December 1951.

January 19

▲ Based on reports from companies having 93 per cent capacity for the steel industry, the operating rate for the week beginning January 19th is scheduled at 99.1 per cent of capacity. This is equivalent to 2,234,000 tons of steel ingots and castings compared with actual production of 2,238,000 tons one week ago.

January 20

▲ Ceiling price increases of ½¢ a lb for primary aluminum pig and ingot, and 4 per cent on fabricated aluminum products were granted to Aluminum Co. of America, Reynolds Metals Co. and Kaiser Aluminum.

▲ In November, United States exports declined to $1,177,700,000, which was $210,000,000 less than the same period in 1951. Imports were valued at $803,800,000 in November, or $15,000,000 less than the same period in 1951.

▲ A bill was passed by the House to continue duty-free imports of copper until June 30, 1954.

January 21

▲ Rex Murdock of New Mexico and New York, a shareholder of Follansbee Steel Corp., filed suit against the company charging "breaches of warranty" in Follansbee's acquisition of Federal Enameling & Stamping Co. in 1948.

January 22

▲ The American Iron and Steel Institute reported that the iron and steel industry spent a record $1,170,000,000 for expansions and improvements in 1952.

▲ The DPA authorized a quick tax write-off of $65,000,000 on new primary aluminum production facilities for Harvey Machine Co., the third new company to enter this field in a year.

▲ Under a new development plan Volta Redonda Steel in Brazil is aiming for 1,000,000 tons of ingots annually, and hopes to hit this mark by the close of 1954.

▲ Hanna Coal & Ore Corp. and Hanna Nickel Smelting Co. will undertake development and production of nickel ore from a major United States deposit in Oregon through an agreement negotiated by Defense Materials Procurement Agency. Nickel Mountain Mine will be developed at Hanna's expense, however. For construction of smelting facilities, the government will advance up to $25,000,000, for which it will receive up to 47,500 tons of nickel.

▲ West Virginia Steel & Manufacturing Co. of Huntington, West Va., entered the field of basic steel production.

January 26

▲ Industrial production in 1952 was 219 per cent of the 1935-39 average, or equal to the 1951 output.

▲ Based on reports from companies having 93 per cent capacity of the steel industry, the operating rate for the week beginning January 26th is scheduled at 99.3 per cent of capacity. This is equivalent to 2,238,000 tons of ingots and castings compared with 2,248,000 one week ago.

▲ According to the AISC, December bookings of fabricated structural steel totaled 236,264 tons, or a 16 per cent increase over the month of November. Total bookings were 2,503,521 for 1952, and shipments for the year totaled 2,664,255 tons. As of December 31, the backlog of work is 2,152,714 tons.

January 27

▲ The American Iron and Steel Institute reported United States blast furnaces in 1952 produced 62,158,591 net tons of pig iron and ferro alloys, or 9,069,159 tons less than the total production in 1951, which is attributed to the strike. December production was 6,509,536 tons.

▲ The AISI announced the production of alloy steel ingots and castings, including stainless, totaled 9,108,335 net tons in 1952.

January 28

▲ Leo M. Harvey, president of Harvey Machine Co. announced that the company plans to build an aluminum rolling mill to produce sheet, strip and circular shapes at an estimated cost of $20,000,000, which will have a 60,000,000 lb capacity of aluminum products annually. This mill will be built on the West Coast.

▲ For the final three months in 1952, United States Steel Corp.'s shipments amounted to 6,626,688 tons. Net profits dropped to $1.60 a common share, compared with $1.64 for the same period in 1951. For 1952, net profits dropped to $4.56 a share compared with $6.10 in 1951.

▲ The price of zinc dropped ½¢ a lb to 12¢ a lb in East St. Louis.

▲ Kaiser Steel Corp.'s net earnings after taxes totaled $3,623,657, or 77¢ a share of common stock.

January 29

▲ The FTC charged United States Steel, Jones & Laughlin, Inland, Republic and Rheem Mfg. Co. with violating anti-trust laws for joining together to fix standards and prices in the sale of steel drums.

▲ OPS granted Kaiser Steel Corp., ceiling price increases of $1.00 to $4.00 per ton on the base price of strip, structural shapes, and plates in order to raise the company's delivered prices to competitive levels.

▲ The Youngstown Sheet & Tube Co. announced net income after taxes for the year 1952 of $22,915,822 or $6.84 per common share, compared with $9.15 in 1951. Total sales amounted to $439,623,183.

January 30

▲ Inland Steel Co. announced net income for 1952 of $23,755,218 after taxes, which is equal to $4.85 per share on common stock, compared with $7.02 in 1951. Consolidated sales for 1952 totaled $458,043,269.

▲ Preliminary report of Bethlehem Steel Co. for 1952 shows net income after taxes of $90,900,771 equivalent to $8.80 a common share, compared with $10.43 in 1951. Net sales for 1952 were $1,691,732,135.

▲ Jones & Laughlin Steel Corp. announced net income for 1952 of $19,482,000 after taxes, equivalent to $2.91 per share of common stock, compared with $4.76 in 1951. Sales for the year amounted to $495,401,000.

January 31

▲ The ICC approved a new formula for dividing revenues on freight rail shipments between the East and the South. Eastern railroads will benefit by increasing revenues about $40,000,000 annually.

▲ The Wheland Co. of Chattanooga, Tenn. will be the fourth new company to be brought into aluminum production, and the DPA will issue a certificate of necessity to permit quick tax write-off on $70,000,000 for alumina and primary aluminum reduction facilities.

▲ Stockholders of the Superior Steel Corp. will vote on privately selling 15,000 shares of $100 par preferred stock and $2,000,000 of long term installment notes on February 24.

▲ Estimated net income in 1952 of leading United States oil companies will reach $2,015,000,000, or 3.6 per cent less than 1951. An estimated 7,700,000 bbl of petroleum products were consumed daily in 1952.

▲ Sharon Steel Corp. announced that consolidated net income for the year 1952 totaled $5,120,414, or equivalent to $4.65 per share of common stock, compared with $8.06 a share in 1951.

▲ In a preliminary report National Steel Corp. reported net earnings for the year 1952 of $37,559,477 equivalent to $5.10 per share of common stock, compared with $6.15 a share in 1951.

CALL Curry!

FOR STEEL PLANT EQUIPMENT

WHAT STEEL PLANT EQUIPMENT DO YOU NEED? LET *Curry* SUPPLY IT — OR LOCATE IT FOR YOU!

Send us a list of your steel plant equipment requirements. If we do not already have it, we can get it for you. Our contacts throughout the iron and steel industry enable us to locate promptly —good, usable equipment that will give you long, dependable service, at great savings in cost. When writing or calling about these ask for the complete *Curry List*. You'll find exactly what you need—and you'll find it pays to buy steel plant equipment through Curry.

2½" & 20" x 7½" REVERSING COLD REDUCTION STECKEL MILL, complete with Recoiling Equipment, Main Drive Motor, Motor-Generator Set, Controls and Spare Parts.

2000 H.P., G.E. SLIP RING MILL TYPE MOTOR, 3/60/2300 v 237 RPM, complete with Liquid Slip Regulator and all controls necessary for mill type operation, including Filtered Air Cooling System.

75-TON MORGAN LADLE CRANE. WITH 25-TON AUXILIARY. 4-Girder Construction. Span 49'6". Motors & Controls for 230v. DC operation.

18"/21" 3-HIGH BAR MILL, complete with Pinion Stand, Gear Reduction Unit, 2500 H.P. Motor, Billet Heating Furnace, Tables and Electric Equipment.

500 H.P. FALK GEAR REDUCTION UNIT. Ratio 18.6 to 1, for 31 RPM output.

80" HYDRAULIC STRETCHER LEVELLER, Capacity 80" wide x 200" long, complete with all Hydraulic Pumps, Controls, and Motor.

400 H.P. GEAR REDUCTION UNIT (WESTINGHOUSE), Single Reduction, Helical Gears, Ratio 6 to 1.

600 H. P. GEAR REDUCTION UNIT (FARREL-BIRMINGHAM), Ratio 2.95 to 1, Single Reduction, Rebuilt 1950.

300 H.P. GEAR REDUCTION UNIT (LEWIS FOUNDRY & MACHINE CO.), Ratio 13.5 to 1, Double Reduction.

156" x ¼" UNITED ENGINEERING & FOUNDRY COMPANY, Power Squaring Shear arranged for 10 H.P. motor, 26 cuts/min.

PORTABLE ALLIGATOR CROP SHEAR 7½" Knives, Reconditioned.

D & K No. 2 ALLIGATOR SHEAR, 21" Knives, 7½ H.P. 3/60/220-440V Motor.

5 TON OVERHEAD ELECTRIC CRANE, 47' Span D.C. Cab Operated.

Write today for the Curry List of Available Steel Plant Equipment!

ALBERT Curry & CO., INC.

STEEL PLANT EQUIPMENT

Cable Address — Curmill Pittsburgh

940 OLIVER BUILDING • PHONE ATLANTIC 1-1370
PITTSBURGH 22, PA.

PINPOINT SAFETY HAZARDS

Type 17540 Gyralite with single sealed beam lamp, mounted in gyrating mechanism.

WITH HIGH INTENSITY ROTATING LIGHT BEAMS

GYRALITES

THE NEW ACTIVATED VISUAL WARNING SIGNALS

Type 15100 Gyralite, for low voltage duty with rotating glass reflector, projects high-intensity colored or clear beam which rotates with a wide, circular sweeping action. Available with a plain or prismatic lens for beam pattern control.

The Gyralite flashes . . . every eye within range of danger sees and PINPOINTS the safety hazard instantly!

Pyle-National's new compact and reliable Gyralites are the best answer to your warning signal problem when noise levels are too high for sound signals, or where confusion might result from the use of too many sound signals.

Gyralites are easily installed on overhead cranes and other hazardous moving equipment, such as plant locomotives, scale cars, transfer cars and other material handling vehicles. Portable Gyralites can be placed on the ground pointing toward crane or equipment operators to warn of temporary construction or repair crews . . . and at hazardous doorways, crosswalks, open pits and manholes.

Gyralites when automatically controlled by a time switch, pressure switch, float switch or an electric eye, etc., make excellent alarms for safeguarding equipment and personnel in innumerable plant operations.

For full information on Gyralites, write now for Bulletin No. 5015.

THE PYLE-NATIONAL COMPANY

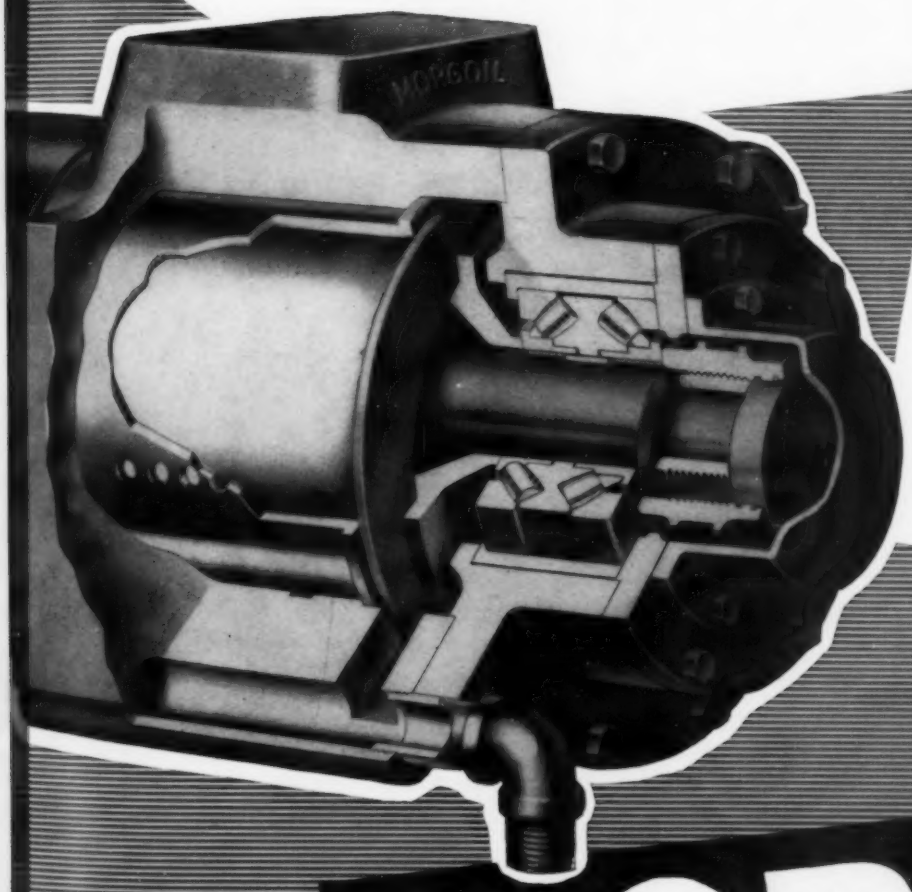
1383 NORTH KOSTNER AVENUE, CHICAGO 51, ILLINOIS

District Offices and Representatives in Principal Cities of the United States.
Export Department: International Railways Supply Co., 30 Church St., New York.
Canadian Agent: The Holden Co., Ltd., Montreal.

FLOODLIGHTS · SAFETY SWITCHES · PLUGS AND RECEPTACLES · PYLET CONDUIT FITTINGS · MULTI-VENT AIR DISTRIBUTION

A Seldom Needed Service

Morgoil Bearings are so designed and so accurately manufactured that "service" in the usual sense is seldom—if ever—needed. Infrequently we do find some conditions that prevent Morgoils from giving their best. The duty of our servicemen is to spot and point out those conditions. Prompt attention will permit Morgoils to give their usual unexcelled performance. If you suspect that you are not getting the most out of your bearings let one of our Morgoil engineers make a courtesy survey. It may prove very profitable.



MORGAN CONSTRUCTION CO.
WORCESTER, MASSACHUSETTS

ROLLING MILLS - MORGOIL BEARINGS
WIRE MILLS - GAS PRODUCERS - EJECTORS
REGENERATIVE FURNACE CONTROL

English Representative: International Construction Company, Ltd.
56 Kingsway, London, W.C. 2, England

MB-22

MORGOIL
ROLL NECK BEARINGS

NEVER BEFORE

anything like this on stripper cranes

- **Special electrical counterweight (counter torque device developed by The Alliance Machine Company, prevents ingots from falling, inflicting damage to buggies and also automatically prevents slack cable during stripping operation.)**
- **Eliminates heavy, hazardous counterweights.**
- **Due to a unique lubricating device, the ample size bronze nut gives many years of trouble-free service.**
- **All gears are enclosed and run in oil.**
- **Cab provides operator with maximum visibility and safety.**

There are many reasons why it pays to consult Alliance when you are planning to install material-handling equipment. Over half a century of experience building cranes and mill machinery is always at your disposal.

World's Largest Builders of World's Largest Cranes

LADLE CRANES · GANTRY CRANES · FORGING MANIPULATORS · SOAKING PIT CRANES
STRIPPER CRANES · SLAB AND BILLET CHARGING MACHINES · OPEN HEARTH CHARGING MACHINES · SPECIAL MILL MACHINERY · STRUCTURAL FABRICATION · COKE PUSHERS

THE ALLIANCE MACHINE COMPANY

Main Office, ALLIANCE, OHIO · Pittsburgh Office, 1622 OLIVER BLDG., PITTSBURGH, PA.

Alliance

Industry News...

COLORADO FUEL AND IRON CORP. ANNOUNCES ACQUISITION OF J. A. ROEBLING CONCERN

▲ Colorado Fuel and Iron Corp., the nation's ninth largest steel producer, has completed the acquisition of the plants, inventories and business of John A. Roebling's Sons Co., Trenton, N. J., it was announced by Charles Allen, Jr., chairman of Colorado Fuel and Iron. The Roebling properties will be operated by John A. Roebling's Sons Corp., a newly-formed and wholly-owned subsidiary of Colorado Fuel and Iron.

At a meeting of the Board of Directors of the new Roebling Corp. held in Trenton, N. J., Mr. Allen was named chairman of the board, A. F. Franz was named president, and Charles Roebling Tyson, executive vice president. The present eleven members of the Colorado Fuel and Iron Corp. board of directors were elected to the Roebling Corp. board of directors in addition to Mr. Tyson. Mr. Franz is president of Colorado Fuel and Iron, and Mr. Tyson served as president of the Roebling concern from 1944 until its acquisition by Colorado Fuel and Iron.

Mr. Allen said that the acquisition of the Roebling business would bring the consolidated annual sales volume of Colorado Fuel and Iron close to the $300 million mark.

The Roebling transaction is a further step in the product and geographical diversification of Colorado Fuel and Iron, long one of the nation's leading steel producers. As part of this diversification program, Colorado Fuel and Iron has in recent years acquired steel plate production facilities in Claymont, Delaware, and is now completing a new $30 million seamless pipe mill at its fully integrated Pueblo, Colorado plant. Colorado Fuel and Iron also operates an integrated steel plant in Buffalo, New York, and has seven other plants in Massachusetts, Pennsylvania, and California.

The Roebling organization was founded in 1841 by John August Roebling, an immigrant from Germany. The firm won an international reputation in 1855 by building the first successful railway suspension bridge in history, spanning the gorge of the Niagara River.

NEW TURBO-BLOWER IS INSPECTED AT DE LAVAL

▲ One of the largest blast furnace turbo-blowers ever built in this country was opened for inspection to steel mill and engineering company representatives at inspection ceremonies recently held at the De Laval Steam Turbine Co. plant in Trenton, N. J. where the new unit was built.

The giant blower, which is one of a pair manufactured for the Armco Steel Corp., is a 5-stage unit with a rated capacity to deliver 121,000 cfm of air at 35 lbs psig discharge pressure. It will be driven by a 15,220 hp —2500 rpm De Laval 16-stage steam turbine under operating steam conditions of 400 lbs psi, 750 F with 28 in. vac.

Total weight of the turbine and blower is over 167 tons with the blower unit making up over 212,000 lb of this weight. Shafts of the turbine and blower were made large and heavy to meet the wide range of varying speed conditions required in blast furnace service. Outside diameter of the blower casing is 12 ft and is divided horizontally in the plane of the shaft. This permits raising the upper half of the casing for easy access to all interior parts.

AISE ESTABLISHES GRADUATE FELLOWSHIP

▲ As part of its expanding research and educational program, the Association of Iron and Steel Engineers, with headquarters in Pittsburgh, Pa., is establishing a Fellowship for graduate study and research at the Carnegie Institute of Technology.

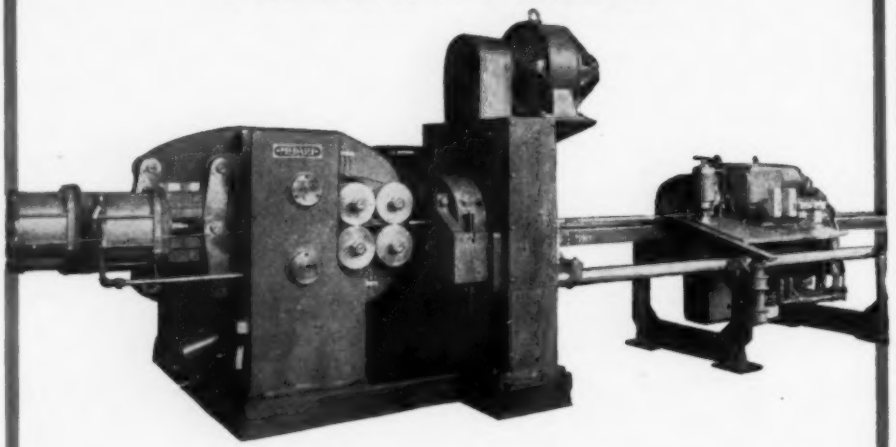
Attending inspection ceremonies were representatives of: U. S. Steel Corp., Jones & Laughlin Steel Corp., Dravo Corp., Alan Wood Steel Co., Turbine Equipment Co., United Engineers & Constructors, Stapp Engineering Co., John A. Roebling's & Sons, Tata, Inc., U. S. Naval Aeronautical Turbine Testing Station, West Trenton, N. J., Purser & London, Inc., Chase National Bank, Canadian Furnace Co., Ltd., and Crucible Steel Co.

Triple Production or Better on Bar & Tube Turning!

MEDART

RFPD AUTOMATIC CENTERLESS BAR TURNERS

FOR BARS ¼" to 6" DIAMETER



▶ The unsurpassed production speeds of the RFPD Turner using carbide cutting tools—up to 12 ft. per minute—average from 3 to 4 times that of conventional turners by actual comparison.

▶ Material turned on this machine can be sold directly from the machine for "as turned" stock, put through the Medart two-roll rotary straightening, sizing and polishing machines for "turned and polished" stock, or given one pass through a centerless grinder for "ground" stock.

▶ The RFPD turning gives 100% material recovery with short, easy-to-handle chips.

▶ Direct-drive cutterhead, through single V-belt drive, is a single compact unit designed for either brazed tip or mechanically held carbide tools.

▶ Controls provide fully automatic push-button operation through entire cycle, and supplementary manual operation for setup. Both speeds and feeds are infinitely variable.

Many other cost-reducing, time-saving exclusives are offered in the RFPD Centerless Bar Turner.

Write For Illustrated Brochure

THE MEDART COMPANY 3535 De Kalb Street St. Louis 18, Mo.

The purpose of the Fellowship is to select and train outstanding men for engineering in the iron and steel industry. Candidates must have outstanding technical ability and demonstrated capacity for leadership.

The Fellowship carries a stipend of $1500 annually for a single man, or $2100 for a married man, plus tuition and allowance for equipment, for study toward advanced degrees.

Applications must be sent to the Dean of Graduate Studies, Carnegie Institute of Technology, Pittsburgh 13, Pa.

NEW GENERATOR TO BE LIQUID-COOLED

▲ General Electric Co. will manufacture the first large generator with liquid-cooled conductors in the history of the electrical industry, it was announced by Glenn B. Warren, vice president of the company and general manager of the turbine division.

A new method of circulating a liquid through hollow conductors will be used in the stator of a turbine-generator set for the new Eastlake power plant of the Cleveland Electric Illuminating Co.

The unit, consisting of a tandem-compound turbine rated at 208,000 kw and a generator rated at 260,000 kva-amp, will be one of the largest in the world.

In making the announcement, Mr. Warren said that this type of liquid cooling makes possible a significant increase in capability of generators without increasing physical dimensions of the units. The higher capability results from more efficient removal of heat produced during the generation of electricity.

The present method of cooling large generators is to circulate hydrogen gas through passages in the magnetic portions of the rotor and stator. Developed by GE, this method is highly efficient for units up to approximately 230,000 kva capability at 3600 rpm.

The liquid cooling method makes possible the design and manufacture of generator armatures having much higher capability than present units.

Other technical features of the Cleveland machine include direct cooling of the rotating field winding with hydrogen, a new and improved grain-oriented strip steel in the mag-

BIG Magnet *Pays Off* with BIG Lifts

TYPE SW ALL-WELDED LIFTING MAGNET HAS THESE IMPROVEMENTS

1. Leads protected at magnet-end.
2. If damaged, outer leads replaceable without entering terminal-boxes.
3. Solderless clasp-type connectors.
4. Stronger welds—2 to 5 times stronger.
5. ECAMICA board (new EC&M development) insulates coil layers.
6. New, purer asbestos, strengthened by EC&M No. 281 impregnation, insulates between turns.
7. Coil windings locked against movement.
8. Thicker pole shoes with high shoulders.
9. Stronger manganese bottom plate.
10. Two terminal chambers—coil-leads on outside of coil.

"Best Magnet We Ever Had—and We've Had Lots of 'Em!" That's what Abe Knofsky, Warren Scrap Iron and Metal Co. of Warren, Ohio, says . . . also, "Its greater lifting capacity means *quicker lifting* and *lower cost per carload.*"

This company uses a 55-inch Type SW Magnet, on a 30-ton Browning Crane and Shovel Type ML-300 Crane with 60-foot boom, for loading various kinds of scrap into railroad cars.

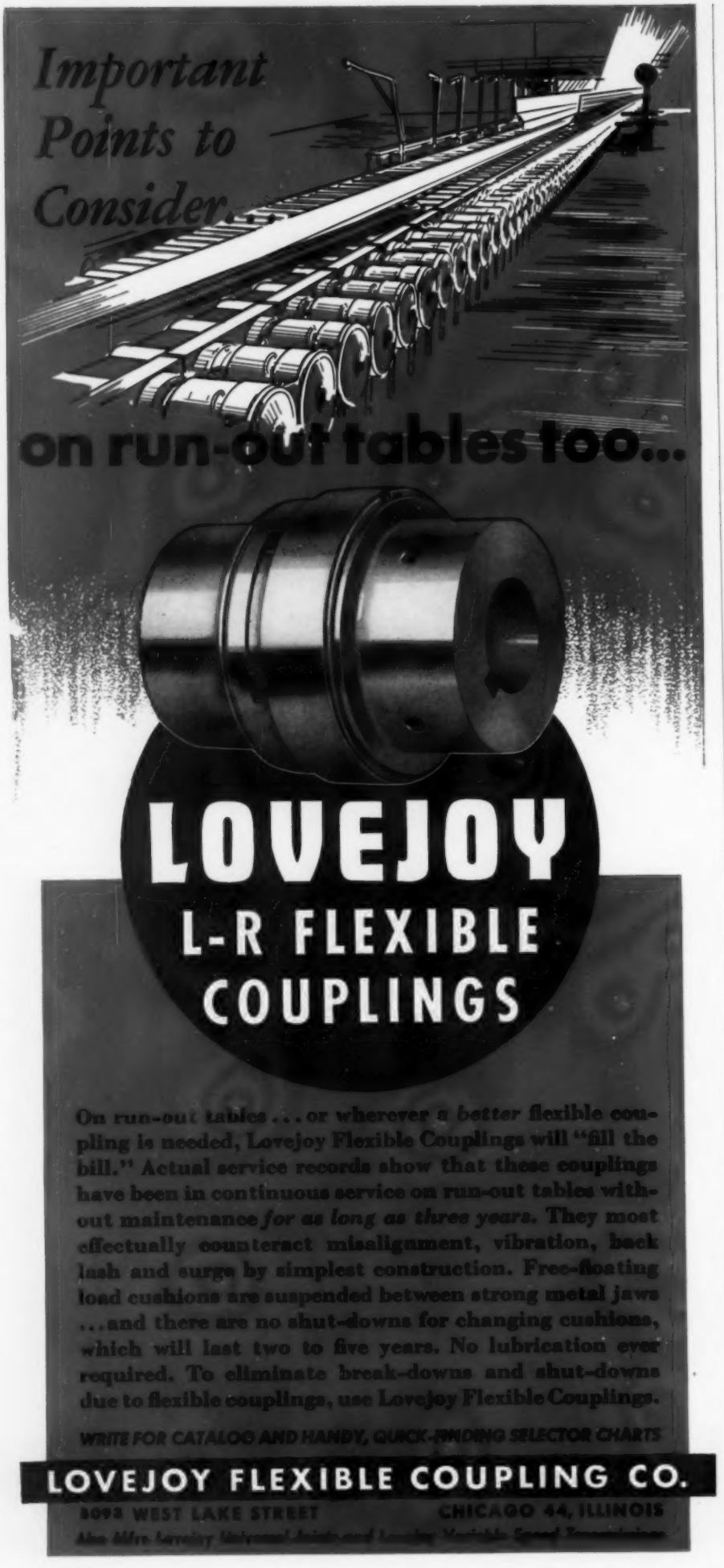
EC&M *Improved Design* Type SW ALL WELDED Magnets give *greater lifting capacity per dollar invested.*

IT WILL PAY YOU TO INVESTIGATE THEM

ASK FOR NEW BULLETIN ▶ 900

THE ELECTRIC CONTROLLER & MFG. CO.

2698 EAST 79TH STREET ★ CLEVELAND 4, OHIO


Important Points to Consider
on run-out tables too...
LOVEJOY
L-R FLEXIBLE COUPLINGS
On run-out tables . . . or wherever a *better* flexible coupling is needed, Lovejoy Flexible Couplings will "fill the bill." Actual service records show that these couplings have been in continuous service on run-out tables without maintenance *for as long as three years.* They most effectually counteract misalignment, vibration, back lash and surge by simplest construction. Free-floating load cushions are suspended between strong metal jaws ...and there are no shut-downs for changing cushions, which will last two to five years. No lubrication ever required. To eliminate break-downs and shut-downs due to flexible couplings, use Lovejoy Flexible Couplings.
WRITE FOR CATALOG AND HANDY, QUICK-FINDING SELECTOR CHARTS
LOVEJOY FLEXIBLE COUPLING CO.
3093 WEST LAKE STREET CHICAGO 44, ILLINOIS

netic portion of the armature, and an improved type of insulation.

GE is also supplying three conventional hydrogen-cooled units, each of 125,000 kw capacity, for the Eastlake plant, which will go into operation this summer. The 208,000 kw generator is scheduled for installation by the end of 1955.

REPUBLIC WILL ENTER STEEL KITCHEN MARKET

▲ Republic Steel Corp., Cleveland, Ohio, will manufacture and market a new line of steel kitchens under its own trade name early this spring, C. M. White, president, announced recently.

"The new steel kitchens will be fabricated by Republic's Berger Manufacturing Division at Canton, Ohio, where more than $1,000,000 has been spent retooling Berger Plant No. 2," Mr. White said.

R. W. Helms, general manager of sales for Berger Manufacturing Division, will direct the new steel kitchen program, which has been under development for more than a year.

To enter the steel kitchen market, which has been estimated at $200,000,000 annually, Republic is creating a new nation-wide sales organization with distributors and dealers located throughout the United States. The new kitchen program will constitute the first "ore to store" operation in the steel kitchen industry.

Republic has its own ore and coal mines, vessel transportation and large steel making and finishing facilities. It has long been recognized as a top producer of all types of quality steels, carbon, alloy and stainless.

BABCOCK & WILCOX BUYS SITE IN NORTH CAROLINA

▲ Babcock & Wilcox Co. has purchased a tract of land south of the city of Wilmington, N. C. and will start immediately to erect a new $2,000,000 plant there to build boilers and related equipment.

The property purchased is 153 acres in what is known as the Maffitt Village development. This will be the second plant of the company to be located in Wilmington, and the fifth new plant to be added to the company's boiler division in a little over

ECLIPSE FUEL ENGINEERING WRITES:

"Heat Prover Completed a 30 Hour Burner Test In Just 6 Hours!"

Amazing Cities Service Heat Prover Works 5 Times As Fast As Old Method... More Accurate, Too!

Robert W. Pixler, Laboratory Supervisor for Eclipse Fuel Engineering Company, Rockford, Illinois writes:

"It did not seem possible that an instrument that is so fast and direct-reading could possibly have the accuracy we demand. But, we found the Heat Prover equally exact, possibly even more exact, than standard commercial testing equipment.

"Our test work with previous instruments was a long, drawn-out affair. But with the Heat Prover, we completed what would normally have been a 30-hour test in just 6 hours! ...and we doubt that our old equipment could have maintained the accuracy delivered by Cities Service Heat Prover."

WHEREVER A FURNACE OPERATION IS INVOLVED, the Heat Prover can help increase productivity by providing:

- **Rapid, continuous sampling**
- **Simultaneous reading of oxygen and combustibles**
- **Direct measurement of oxygen and combustibles**
- **Easy portability**
- **No maintenance; no re-calibration**

For details, contact nearest Cities Service office or write Cities Service Oil Company, Dept. B11, Sixtv Wall Tower, New York City 5, N. Y.

CITIES SERVICE

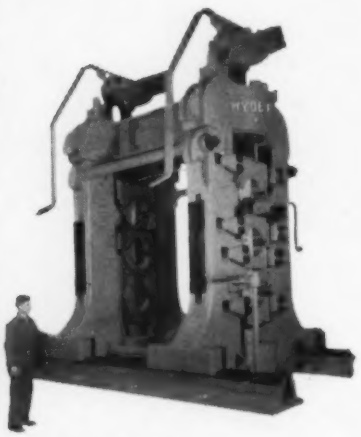
QUALITY PETROLEUM PRODUCTS

Hyde Park

RED CIRCLE Rolls ALLOY-CHILLED

Rolling Mill Equipment

Outstanding in quality and in performance Hyde Park Rolling Mill Equipment has enjoyed the respect of the industry for more than fifty years.



Bar Mills
Merchant Mills
Sheet and Strip Mills
Pinion Stands
Roller Tables
Reduction Drives
Stretcher Levellers
Guillotine Shears
Sheet Mill Shears
Roll Lathes
Special Machinery
Machine Work

Hyde Park

FOUNDRY & MACHINE CO.
Hyde Park, Westmoreland County, Pa.
ROLLS
ROLLING MILL MACHINERY
GREY IRON CASTINGS

a year, making a total of seven plants in the division.

The total area under roof will be about 135,000 sq ft composed of three bays 500 ft by 90 ft. In addition, there will be 1500 ft of uncovered craneway. The plant will do such operations in the fabrication of large industrial boilers as bending tubes, building drums and headers, and assembling reheater sections.

20,000-TON EXTRUSION PRESS LEASED BY ALCOA

▲ Aluminum Co. of America announced that its plant at Lafayette, Ind., has been awarded a contract for a 20,000-ton extrusion press under a lease arrangement with the U. S Air Force.

The 20,000-ton press, in addition to a 14,000-ton press now being installed here as part of the same program, will produce huge extruded shapes for military and civilian aircraft. Wide, ribbed shapes for integrally stiffened wing panels and heavy shapes for spar caps will be the specialty items on the press, it also will be capable of producing wide, thin shapes for building curtain-wall construction as well as large size pipe for the chemical and petroleum industries. The press is scheduled for completion by mid-1954.

To relieve internal strains in the shapes and to straighten them after extrusion Alcoa already has scheduled installation of a 3,000,000 lb stretcher. It will straighten shapes up to 60 sq in. in cross-sectional area in one of the strongest aircraft alloys, 75S.

KAISER UNVEILS NINTH OPEN HEARTH AT FONTANA

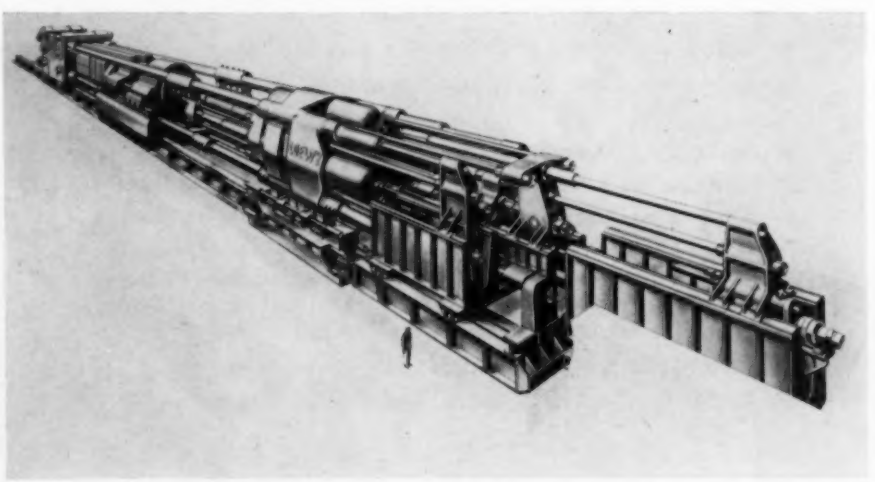
▲ Kaiser Steel Corp., Fontana, Calif., has started its eleventh year by placing in operation a ninth open hearth furnace, a major unit of its current $65,000,000 expansion program, according to an announcement by George B. McMeans, vice-president in charge of operations. Producing 225 tons of steel every ten hours, the large furnace will boost Fontana's steel capacity to 1,536,000 tons of ingot steel annually.

Largest item in the current expansion program is a third blast furnace, due for completion in early spring. The blast furnaces at Fontana are the only such units on the West Coast.

This expansion also sees work progressing in the raw materials handling departments at the plant, which are preparing for a 50 per cent increase in tonnage of iron ore and 75 per cent increase in coal received from the mines.

Also being prepared for early operation are 90 additional coke ovens. These ovens will supply coke for the blast furnaces and the raw materials for Kaiser's growing by-products plant that supplies ammonium sulphate for fertilizer; also benzol, toluol, tar products and many other chemicals needed by local industries.

Note the size of the man in this perspective drawing of the 20,000-ton extrusion press which will be installed at Aluminum Co. of America's Lafayette, Ind., works. The giant press under lease from the U. S. Air Force will push out 2¼ ton extruded shapes for the aircraft industry. Aluminum ingots will range in size from 18 to 41 in. in diameter and nearly eight ft in length.



Amazingly simple way to measure BLAST AIR DEW POINT

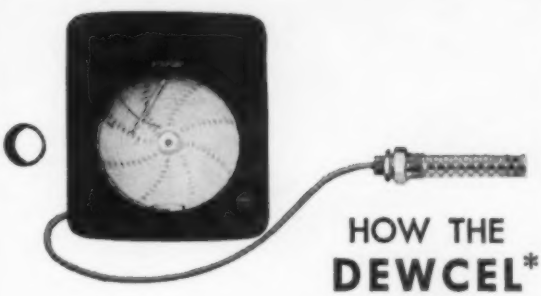
directly . . . accurately . . . continuously

Now you can measure or control the moisture content of blast air with simplicity and accuracy never before obtainable!

The unique Foxboro Dewcel*, an entirely new type humidity-sensitive element, has made this possible, at surprisingly low cost. Coupled with a Foxboro Recorder or Controller, the Dewcel offers these outstanding advantages:

1. Direct recording in dew point temperature, at existing pressure.
2. Wide working range — even operates at sub-zero temperatures.
3. Neither adds nor removes water from atmosphere.
4. No water box or circulation of air required.
5. Simplicity that eliminates maintenance.
6. High sustained accuracy.
7. Initial and operating economy.

Investigate Foxboro Dew Point Control. Write for Bulletin 407, and for Engineering Data Sheet 330-1 covering moisture control for furnace air blast. Foxboro Engineers will be glad to discuss the application of this control to your furnaces, at your convenience. **The Foxboro Company, 582 Neponset Avenue, Foxboro, Mass., U.S.A.**



HOW THE DEWCEL* WORKS

The Dewcel element is a thermometer bulb (liquid-filled or electric-resistance type) jacketed with lithium-chloride-impregnated woven glass tape. Over this are wound two spaced gold or silver wires connected to an AC source. The lithium chloride absorbs moisture, allowing current to flow, generating heat, and raising the temperature. Equilibrium temperature is reached when vapor-pressure of the moist salt exactly balances that of the surrounding air or gas. The System translates this temperature into direct readings of dew point.

Thus, Foxboro Dew Point Instruments give direct readings or control of dew point from —50°F. to 142°F. at working temperatures from —40°F. to 220°F. Readings easily converted to absolute or relative humidity.

*Trade Mark

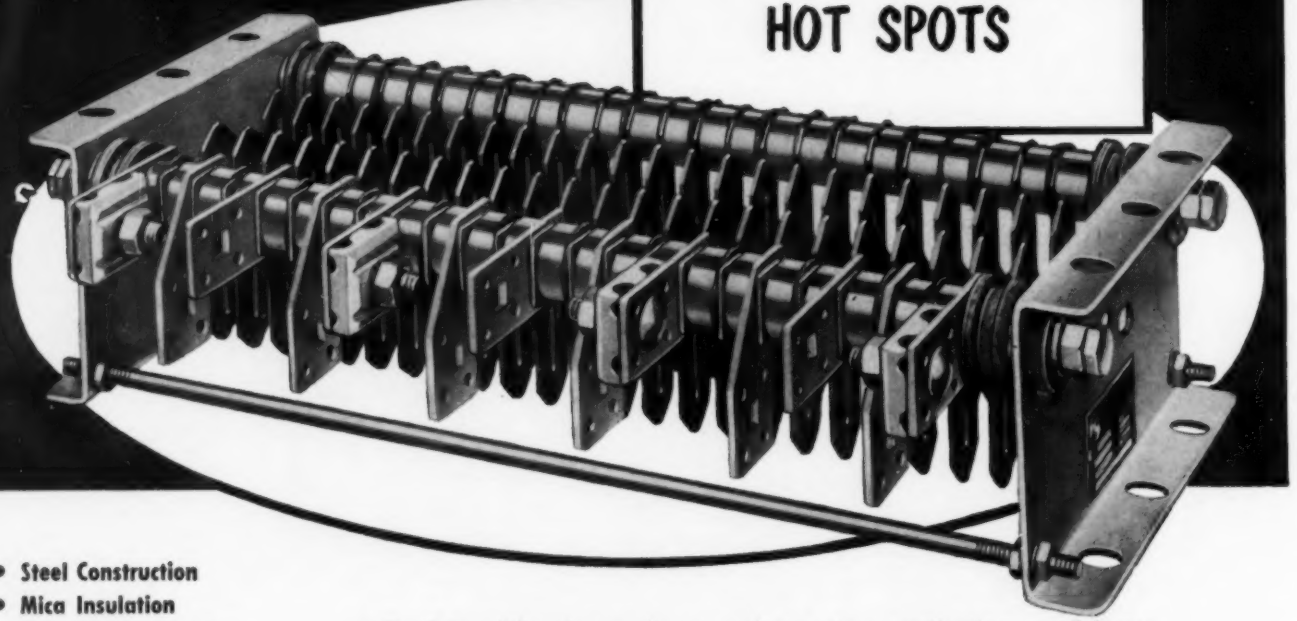
FOXBORO
REG. U. S. PAT. OFF.

RECORDING · CONTROLLING · INDICATING
INSTRUMENTS

FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND

Resistor life depends on adequate ventilation.....

Patented P-G Grid Design eliminates HOT SPOTS



- Steel Construction
- Mica Insulation
- Corrosion Resistant
- Vibration Proof
- Moisture Resistant
- Provision for Expansion
- Adequate Ventilation
- Rugged Terminals

Write for Bulletin No. 500

Resistor life depends on adequate ventilation and how efficiently heat may be dissipated . . . P-G grid design equalizes the amount of air space surrounding each leg or loop to obtain even heat throughout the grid area. (Note illustration.) . . . Since heat is rapidly and evenly dissipated, hot spots fail to develop and longer resistor life is assured . . . For a nonbreakable resistor (only steel and mica used) specify P-G on your next application.

The Nonbreakable Steel Grid Resistor

THE POST-GLOVER ELECTRIC COMPANY

• ESTABLISHED 1892 •

221 WEST THIRD STREET, CINCINNATI 2, OHIO

With the start of operations in mid-1952 of the new tin plate mill capable of producing 200,000 tons of tin plate annually, Kaiser now has nine rolling mills, the products of which are pipe, structural shapes, plate, strip, sheet, bars and other items.

RESEARCH COMPANY TO ENLARGE FACILITIES

▲ New research facilities for Arthur D. Little, Inc., Cambridge, Mass., will be erected on the Concord Turnpike in West Cambridge and will be ready for occupancy by the end of the year, Earl P. Stevenson, president of the well known industrial research and engineering firm announced recently, adding that construction would begin in April.

This new building will be situated in a new industrial area and immediately adjacent to a building recently completed for Little's Mechanical Division and occupied on January first. It will be a two-story, E-shaped structure of almost 60,000 sq ft. Present plans are that it will house the company's experimental operations in physics, chemical engineering, new-product development, and production methods. Additional land is available for further construction. The company's headquarters and its technical-economic research will continue at the present location on Memorial Drive, Cambridge. Design and construction of the new building will be supervised by Cabot, Cabot and Forbes, developers of the industrial area.

WALDRON APPOINTS CANADIAN AGENCY

▲ John Waldron Corp. of New Brunswick, N. J., has announced the appointment of Peacock Brothers, Ltd., to handle all products of the Waldron coupling division in Canada. Peacock Brothers maintain Canadian offices in Montreal, Sydney, Noranda, Toronto, Sudbury, Winnipeg, Calgary and Vancouver.

U. S. FIRMS WILL ADVISE DUTCH RAIL COMPANIES

▲ Three American companies will provide technical assistance enabling three Dutch manufacturers to pro-

MOHR

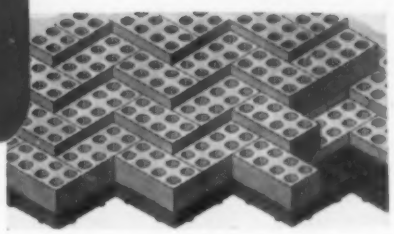
HOT BLAST STOVES

with Exclusive

"Locked-in-all-directions"

Structure

Proved in more than 90 installations since 1938



The unparalleled performance record of Mohr Hot Blast Stoves is due to their structural stability. Sound engineering and exclusive design have created the distinctive Mohr "locked-in-all-directions" structure, typified by the sectional view showing how checker bricks are interlocked. Both horizontal and vertical joints are broken. There are no columns of brick to cork-screw or shift from position—no cut-outs to reduce bearing area—and this stability is accomplished without sacrifice of heating surface or brick volume. The resulting high efficiency and dependability are reflected in the preference for Mohr stoves, with more than 90 installations in operation.

Your inquiry is invited for replacement on existing equipment as well as for new installations. Write for descriptive bulletin.

JOHN MOHR & SONS

3220 East 96th Street, Chicago 17, Illinois

ENGINEERS • FABRICATORS • CONTRACTORS . . . SINCE 1881

duce 100 diesel-electric locomotives valued at approximately $15,000,000 for the Netherlands Railways, it was announced recently by the Westinghouse Electric International Co.

The three-way agreement will enable the Dutch railroad to obtain units which are American in design, except for such details as couplings and buffers. It is a "significant example of how private industry can further the aims of America's Point Four Program" according to F. Q. Den Hollander, president of the Netherlands Railway, who recently visited this country in connection with modernization of his country's rail transportation system.

Heemaf, of Hengelo, largest Dutch electrical manufacturing concern, which has produced electric traction apparatus under Westinghouse license since 1922, has been awarded a contract for the 80-ton road switching units. The company will receive manufacturing information and technical assistance on production of the electrical components from Westinghouse.

Similar information on mechanical components will be provided by the Baldwin-Lima-Hamilton Corp. through Heemaf to Allan, of Rotterdam, where the units will also be assembled.

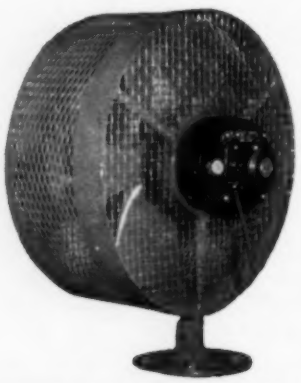
National Supply Co., the third American firm participating in the agreement, will provide information on its diesel engines to Machinefabriek, of Hengelo, where the power plants for the 100 locomotives will be built.

Starting in 1946 with a system that had been virtually destroyed by the war, the Dutch railways have been rebuilt to operate nearly 2,000 miles of track, about the same size as the New York, New Haven and Hartford Railroad.

Electric locomotives and trains and self-propelled diesel electric trains provide the motive power for passenger service, while steam locomotives are used largely for freight. Sixty per cent of the line's revenue comes from passenger service and 40 per cent from freight.

Deliveries of the 100 new locomotives are expected to begin in about two years.

IS HEAT SLOWING UP YOUR WORKMEN?



TRUFLO CRANE CAB FANS
For cooling interiors of crane cabs and other confined areas. Adjustable both horizontally and vertically. Four blade type, 12 and 18 in. sizes.

Keep them COOL with TRUFLO FANS

TRUFLO PORTABLE COOLING FANS
Easily portable. Help keep efficiency high where work is hottest. 12 to 36 inch diameters.

Production suffers when workmen are overheated. Steps begin to drag, efficiency falls.

Now, when speedy production is vital, Truflo Fans can help keep your workmen on their toes. All Truflo Fans are designed and built correctly to put fresh cool air *in large volumes* exactly where it is needed. Perfectly-balanced shafts and blades give more air per h.p. . . . strong steel frames stand up longer under hard use . . . rugged wire guards protect men against injuries.

All of the following types can help beat the heat, keep production moving in your plant. Write for illustrated literature.

PORTABLE COOLING FANS
CRANE CAB FANS • WALL FANS
EXHAUST FANS • BLOWERS
ROOF VENTILATING FANS
PENT HOUSE FANS

TRUFLO FAN COMPANY

245 MAIN ST., HARMONY, PA.

ROTARY HEARTH FURNACE IS INSTALLED AT B & W

▲ George J. Hagan Co., recently completed installation of a rotary hearth bloom heating furnace in the steel mill of the Tubular Products Division of Babcock & Wilcox Tube Co. at Beaver Falls, Pa.

The furnace is equipped with automatic charging and unloading equipment, as well as automatic furnace pressure control, automatic combustion control and automatic temperature control, to provide a completely automatic installation from bloom storage table to the mill.

CHICAGO FIRM PLANS INDUSTRIAL TRUCK RENTAL

▲ The first national plan making possible rental of industrial trucks was announced recently, by John A. Baldinger, general manager of the Automatic Transportation Co., 149 West 87th Street, Chicago, Ill.

Oil Immersed

ROWAN TYPE 800--834 LIGHTING SWITCH

"First choice" for locations where operating requirements are severe and atmospheric conditions dusty, corrosive, or semi-hazardous. Enclosures are designed to meet the requirements of NEMA Type XI, welded construction—fabricated from high quality, cold rolled steel sheets with threaded conduit openings. Simplicity of operation—easy to inspect since the entire mechanism and terminals are readily accessible.

Extra heavy, self-aligning, quick make and quick break, renewable contacts are series break which minimizes concentration of burning. Rowan time-tested AIR-SEAL fuses provide dependable short circuit protection.

Representatives in all principal cities throughout the United States.

Type 800 for use on 3-wire, single phase 115/230 V. circuits.

Type 834 for use on 4-wire, 3 phase, 120/208 V. circuits.

These units are available in 6 and 12 gang units.

ROWAN CONTROL

THE ROWAN CONTROLLER CO., BALTIMORE, MD.

"MULTICUT" "TUFCUT" "HOT WORK"
Wapakoneta
SHEAR BLADES
and ROTARY KNIVES
Any type or size blade of proper Alloy with correct hardness and temper for every type shearing machine and every kind of job.
Rx ENGINEERED TO THE JOB
Every Wapakoneta blade is made to exact specifications, designed for the particular job. Complete records with order number of each blade makes possible duplication of exact size and temper at any time.
The WAPAKONETA MACHINE CO.
Shear Blade Specialists Since 1891
Wapakoneta, Ohio

The plan will be carried out by the Chicago electric industrial truck manufacturer in conjunction with C.I.T. Corp., the industrial financing subsidiary of C.I.T. Financing Corporation.

Automatic will negotiate agreements with potential users through its franchise representatives. C.I.T. then will purchase the equipment from Automatic and lease it to users. Rental contracts for all electric industrial trucks will be for nine years. Contracts for associated equipment, such as batteries and battery chargers, will run from five to nine years.

Installment purchases of equipment are also made possible by the new program. The procedure in this instance resembles automobile financing. After an initial down payment, regular monthly payments are arranged, not to exceed a 36-month term.

OHIO SALES COMPANY FORMS PARTNERSHIP

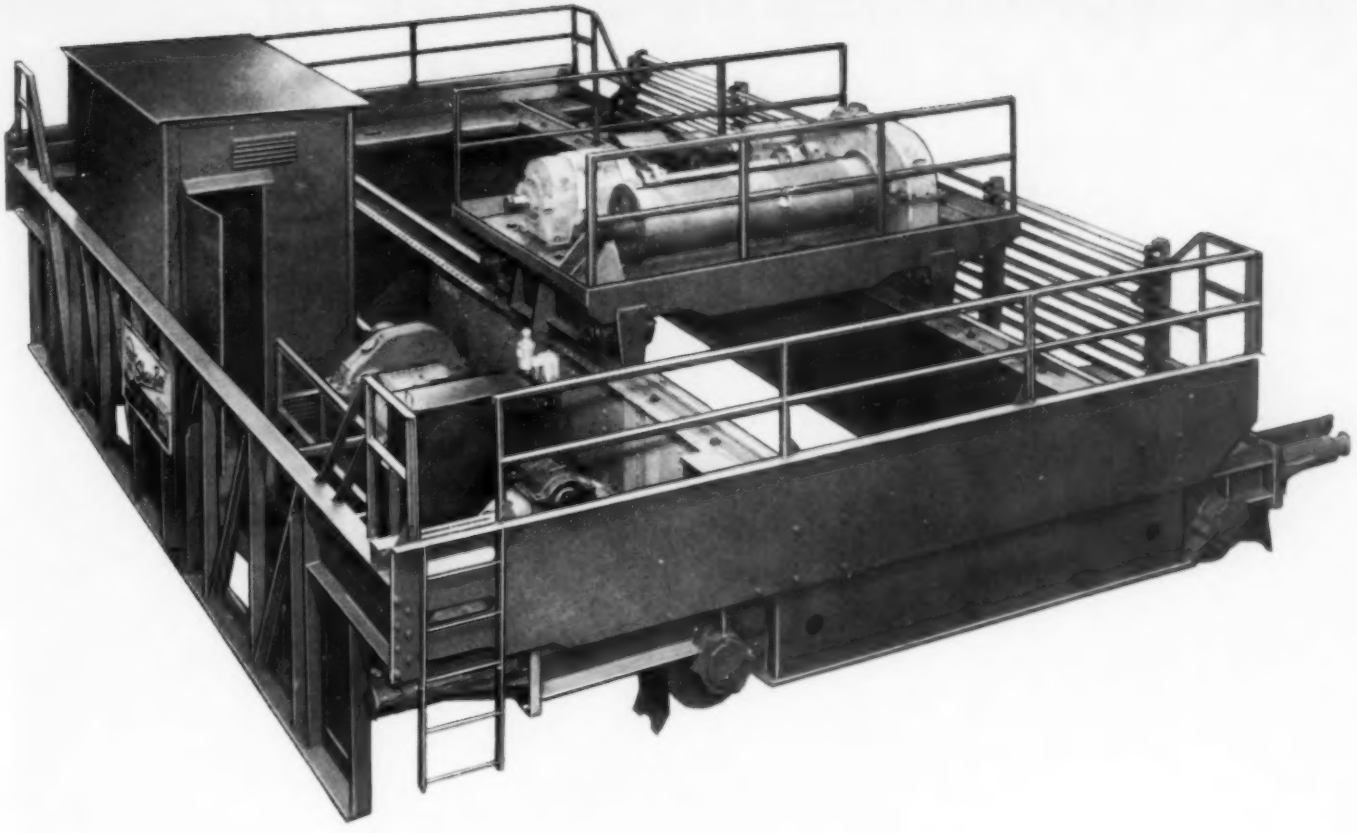
▲ Formation of the partnership Wood-Compton Co. specializing in sale and service of industrial power apparatus has been announced. The new company is direct factory agent for Monitor Controller Division, Ultrasonic Corp., Cambridge, Mass. Warner Electric Brake and Clutch Co., Beloit, Wisc., and Farmer's Engineering & Manufacturing Co. Pittsburgh, Pa. Office is at 25010 Lakeland Blvd., Cleveland 23, Ohio.

Partners in the new enterprise are James E. Wood and William H. Compton. This new company supercedes the J. E. Wood Co. founded in 1919 by Mr. Wood. Territory to be covered by the new agency will be northern Ohio and northwest Pennsylvania.

BAKER-RAULANG BUYS LULL MFG. CORP.

▲ Purchase of the Lull Manufacturing Corp., Minneapolis, Minn., by Baker-Raulang Co., Cleveland manufacturer of industrial lift trucks, tractors and cranes, was announced by Baker president, James W. Moran.

Mr. Moran explained, in making the announcement, that it is planned



STEEL MILL CRANES . . . *To A.I.S.E. Spec's*

When you buy "Shaw-Box" Cranes built to A.I.S.E. Standard No. 6 Spec's, you get cranes built exactly to specifications plus the advantages of "Shaw-Box" engineering and manufacturing techniques. You also get the crane performance, maintenance conveniences, and the fine workmanship for which all "Shaw-Box" cranes are famous.

"Shaw-Box" already has standard A.I.S.E. designs for cranes ranging from 15 to 100 tons capacity. So, you pay less for engineering and get more crane for your crane dollars.

SEND ALL YOUR INQUIRIES FOR CRANES AND SOAKING PIT CARRIAGES TO "SHAW-BOX".

MAXWELL MANNING MOORE INC. MM TRADE MARK

"Shaw-Box" CRANES

MANNING, MAXWELL & MOORE, INC.

Muskegon, Michigan

Builders of "Shaw-Box" Cranes, 'Budgit' and 'Load-Lifter' Hoists and other lifting specialties. Makers of 'Ashcroft' Gauges, 'Hancock' Valves, 'Consolidated' Safety and Relief Valves, and 'American' Industrial Instruments.

Why LINK-BELT belt conveyors are first choice in so many steel mills...

LINK-BELT engineering experience plus quality components combine to cut handling costs

Yes, in steel mills everywhere, Link-Belt is first choice in belt conveyors. Whether your job is large or small, Link-Belt can apply unequalled engineering experience to meet the conditions of your particular bulk handling requirements.

Link-Belt builds a complete line of quality components. Our conveyor engineers can choose from all types and sizes of idlers, trippers and terminal machinery to match your exact requirements.

Link-Belt can also supply all related equipment—other types of conveyors, feeders, elevators, car dumpers and shakers. And Link-Belt will build your supporting structures and enclosures . . . install the job completely if desired.

Link-Belt will gladly work with your engineers, consultants and builders of mill and process equipment. Get in touch with your nearest Link-Belt office.

12.747-F

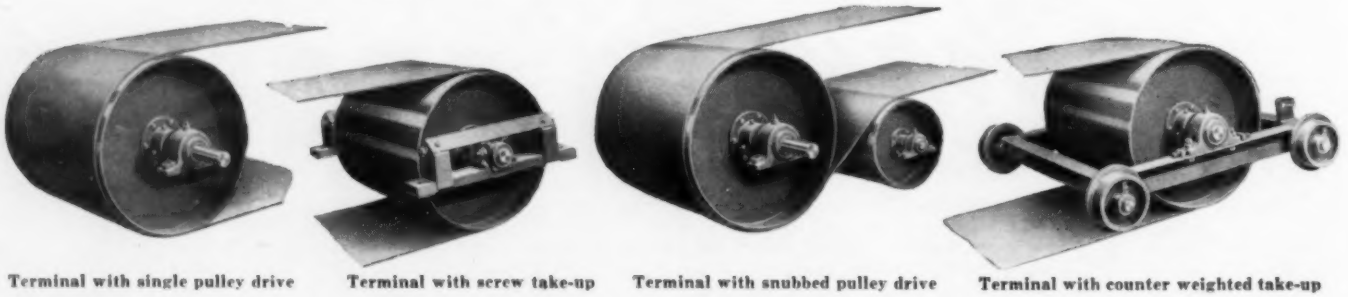
LINK-BELT COMPANY: Plants: Chicago, Indianapolis, Philadelphia, Colmar, Pa., Atlanta, Houston, Minneapolis, San Francisco, Los Angeles, Seattle, Toronto, Springs (South Africa), Sydney (Australia). Sales Offices in Principal Cities.

Magnetite ore is carried from crushing plant on this 1500 ft. long belt conveyor equipped with 48 in. wide Link-Belt roller bearing idlers.

LINK-BELT

BELT CONVEYOR EQUIPMENT

LINK-BELT Pre-Selected Terminals—the right equipment for every requirement



Terminal with single pulley drive | Terminal with screw take-up | Terminal with snubbed pulley drive | Terminal with counter weighted take-up

to operate the Lull organization as a wholly-owned subsidiary of Baker-Raulang under the name of the Baker-Lull Corp. Mr. LeGrand Lull, founder of the Minneapolis company, becomes a director of the new subsidiary and the parent company as well, as a result of the transaction.

This purchase is a move to provide added resources for expansion and development for Lull, and to widen the product lines of the parent company.

The former Lull Corp. produces heavy-duty industrial lift trucks in capacities to 30,000 lb and owns patent rights to the "Travel-loader" —a unique, side-loading lift truck. It also manufactures front-end loading tractors in capacities up to 10,000 lb. Lull also has developed many new types of material handling vehicles for the armed forces in recent years.

In June of last year the Minneapolis manufacturer moved into a new 110,000 sq ft plant. Lull, organized in 1938 to supply attachments for industrial tractors, is expected to enjoy gross sales in excess of $3,000,000 this year.

AIR REDUCTION PLANS LIQUID OXYGEN PLANT

▲ Air Reduction Sales Co., a division of Air Reduction Co., Inc., will soon begin construction of a new liquid oxygen plant in Riverton, N. J., ten miles northeast of Camden.

The new plant, which is scheduled to begin production next year, will primarily serve the Delaware River Basin industrial area. Deliveries of liquid oxygen, supplementing the production of other Air Reduction plants, may be made north to New England and south to the Carolinas.

In addition to oxygen, the plant will also produce nitrogen and argon. The oxygen will be used principally in the oxyacetylene processes for the cutting and welding of metals. Argon, an inert gas, is used primarily in the gas shielded electric arc process and the electronics industry. Nitrogen, also an inert gas, provides an inert atmosphere where fire hazard or chemical oxidation must be avoided.

USE THE ENGINEERING MART

THIS PICTURE TELLS A STORY of a new cost-cutting opportunity for steel mills

Note the ready accessibility of each item of steel in this storage yard of a well-known steel mill. It's this availability of materials that's one of the prime advantages of the ROSS STRADDLE CARRIER handling method . . . an advantage, unmatched by any other method, that eliminates delays, lowers costs and increases the production efficiency of the mill.

ROSS STRADDLE CARRIERS, heart of the Ross unit-load handling system, are built to handle 45,000-pound concentrated loads on around-the-clock schedules in the roughest, toughest steel mill service . . . to put those loads *where* wanted *when* wanted.

Your mill, too, can profit by this modern, flexible mass handling system. Get in touch with Ross today for the complete details.

Rely On ROSS

THE ROSS CARRIER COMPANY

Direct Factory Branches and Dealers Throughout the World

400 MILLER ST., BENTON HARBOR, MICH., U.S.A.

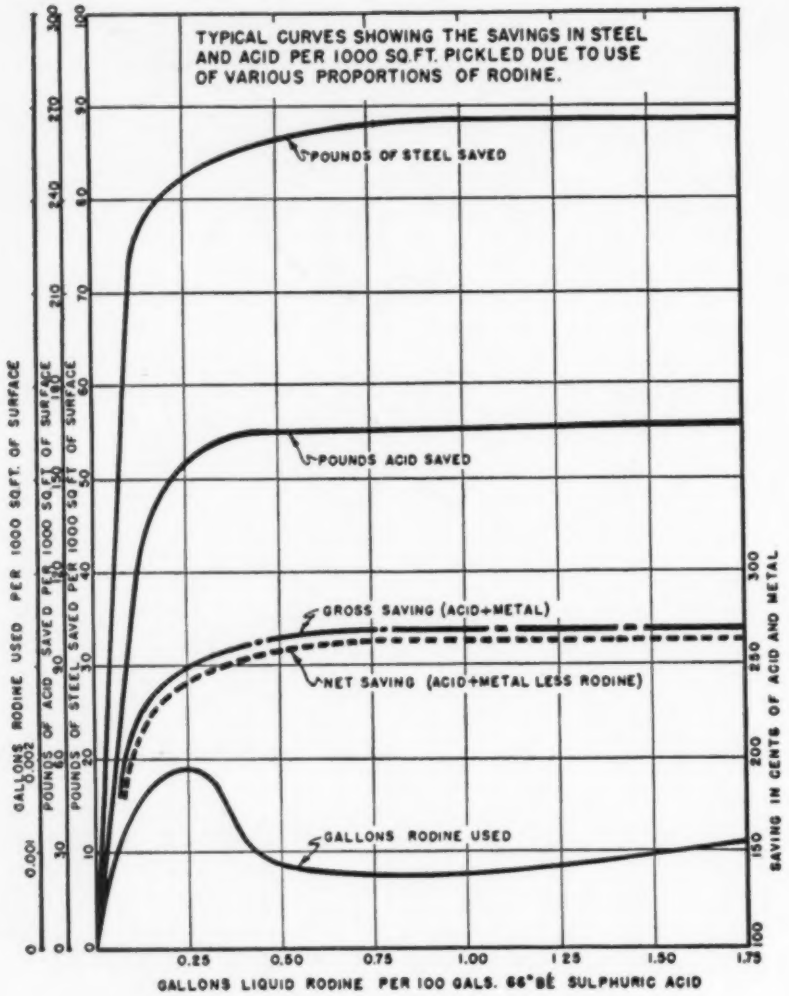
AMERICAN CHEMICAL PAINT COMPANY

AMBLER CHEMICALS ACP PROCESSES PENNA.

Technical Service Data Sheet

Subject: EFFICIENT PICKLING WITH "RODINE"®

A. SAVINGS POSSIBLE WITH "RODINE"


TYPICAL CURVES SHOWING THE SAVINGS IN STEEL AND ACID PER 1000 SQ.FT. PICKLED DUE TO USE OF VARIOUS PROPORTIONS OF RODINE.
POUNDS OF STEEL SAVED
POUNDS ACID SAVED
GROSS SAVING (ACID+METAL)
NET SAVING (ACID+METAL LESS RODINE)
GALLONS RODINE USED
GALLONS RODINE USED PER 1000 SQ.FT. OF SURFACE
POUNDS OF ACID SAVED PER 1000 SQ.FT. OF SURFACE
POUNDS OF STEEL SAVED PER 1000 SQ.FT. OF SURFACE
SAVING IN CENTS OF ACID AND METAL
0.25
0.50
0.75
1.00
1.25
1.50
1.75
GALLONS LIQUID RODINE PER 100 GALS. 66°BÉ SULPHURIC ACID

B. TYPICAL APPLICATION OF "RODINE"

Pickling shell cases in uninhibited muriatic or sulfuric acid contributes to their embrittlement and makes it difficult to draw them without breakage. By adding a small amount of "Rodine" to the pickle bath, embrittlement is suppressed and more than enough acid is saved to pay the costs of the inhibitor.

CHEMICALS ACP PROCESSES WRITE FOR DESCRIPTIVE FOLDER ON "RODINE" AND INFORMATION ON YOUR OWN PICKLING PROBLEM. CHEMICALS ACP PROCESSES

CLAIRTON BATTERY "14" PUSHES FIRST COKE

▲U. S. Steel's Clairton, Pa., Works pushed coke January 29 for the first time at its new No. 14 coke battery.

Part of a long range program started in 1946 to rebuild existing coke oven facilities at the Clairton, Pa., plant, the battery is one of three to be put into operation this year. Next month No. 13 battery will be placed into operation and No. 15 is scheduled for May.

No. 14 battery, constructed by Koppers, has 61 ovens using 1400 tons of coking coal daily. In addition to the approximately 966 tons of coke produced daily destined for blast furnace use in Clairton and other U. S. Steel plants in the Pittsburgh district, coal chemicals are recovered from the gas.

The new gun-flue type battery is equipped with self-sealing doors, newest type oven machinery and double collecting by-product gas mains.

BRASSERT TAKES OVER FURNACE ENGINEERS

▲ Effective February 1, C. Alexander Brassert acquired a controlling interest in Furnace Engineers, Inc., builders of a complete line of industrial furnaces ranging from open hearth and soaking pits to heat treating and reheating units for the steel and other industries.

Furnace Engineers, Inc., will be operated as an associated company of The Brassert Corp., Niles Construction Co. and Standard Boiler & Plate Iron Co.

New officers of Furnace Engineers are: C. Alexander Brassert, chairman of the board; Carlton A. Barrett, president; Nicholas W. Huckestein, vice president and chief engineer; and Stannard B. Pfahl, secretary and treasurer.

General offices will be maintained at 210 Boulevard of the Allies, Pittsburgh, Pa.

With the acquisition of Furnace Engineers, Inc., Mr. Brassert states, "We are now the only organization that can engineer, fabricate and install all types of steel mill furnaces from the blast furnace to the smallest reheating furnace."

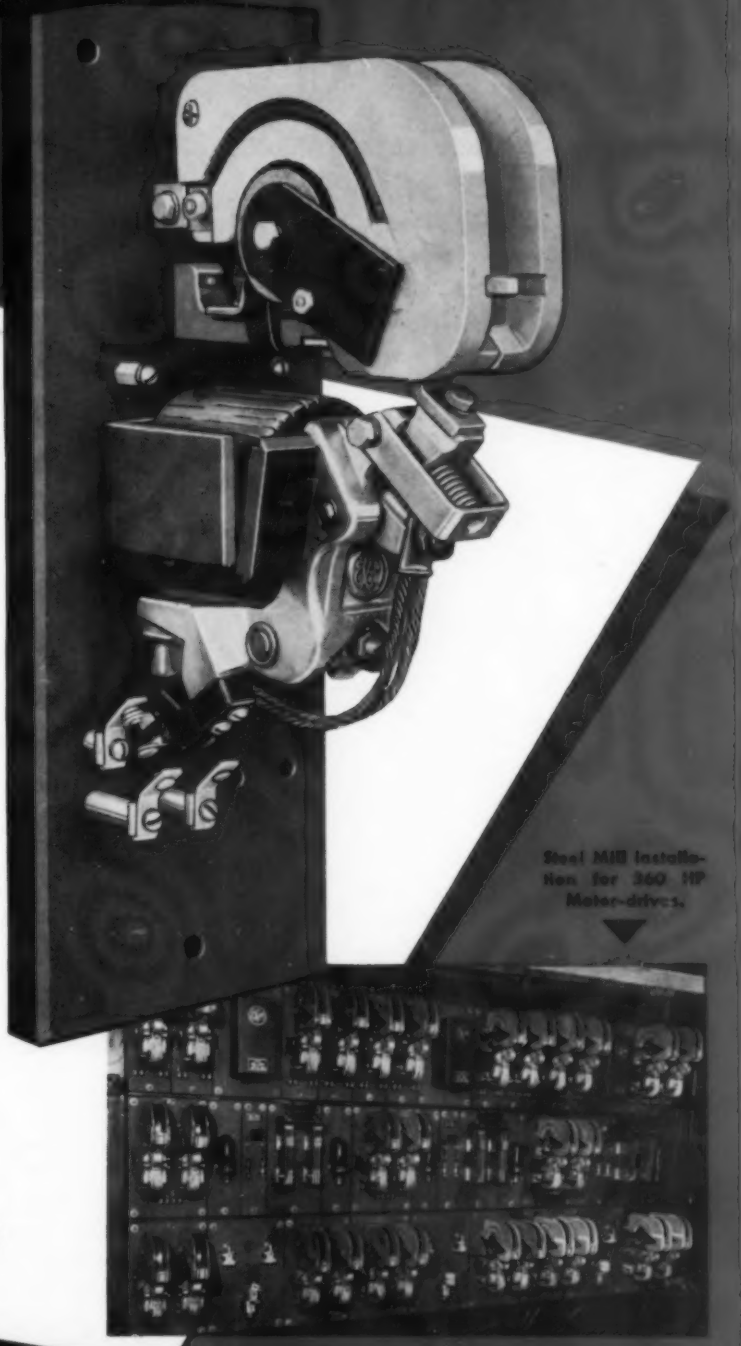
Designed for Low Up-Keep

PROVEN IN HUNDREDS OF PLANTS

EC&M

LINE-ARC

CONTACTORS



Steel Mill Installation for 360 HP Motor-drives.

You can meet production demands better with EC&M Magnetic Controllers, because they are easy to get along with, easy to service on a preventive maintenance basis and low on upkeep.

The LINE-ARC principle keeps costs down and saves maintenance-time. Don't overlook these important advantages when buying mill and crane control:

1. Cool contact operation—longer contact life.
2. Lengthened Arc Shield life — the LINE-ARC principle centers the arc, so that destructive burning is eliminated.
3. Safer electrical interlocks—double-break, coin-silver contacts. The moving normally-open and normally-closed contacts are insulated from each other.
4. Foremost accessibility for inspection and part-replacement—delays prevented because maintenance is encouraged.

It pays to specify EC&M Control

THE ELECTRIC CONTROLLER & MFG. CO.

2698 East 79th Street Cleveland 4, Ohio

42 FURNACES OVER A MILLION TONS...

and still going strong with

NATIONAL CARBON
TRADE-MARK

BLAST FURNACE LININGS

Of these 42 "National" carbon-lined blast furnaces, **13** original linings have produced from 1 to 1½ million tons; **18** from 1½ to 2 millions; **10** have produced between 2 and 2½ millions; and **1** lining has topped the 2½ million ton mark. Every year more "National" carbon goes in . . . *stays* in to produce record tonnages, record low cost and *smooth* operation. More and more, it pays to watch the growth of CARBON in modern steel-making equipment.

•

The term "National" is a registered trade-mark of Union Carbide and Carbon Corporation

NATIONAL CARBON COMPANY
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street, New York 17, New York

District Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

IN CANADA: National Carbon Limited, Montreal, Toronto, Winnipeg

OTHER NATIONAL CARBON PRODUCTS

BLAST FURNACE LININGS • BRICK • CINDER NOTCH LINERS • CINDER NOTCH PLUGS • BRUSHES
ELECTRIC FURNACE ELECTRODES • SPLASH PLATES • RUNOUT TROUGH LINERS • MOLD PLUGS

Personnel News...

William P. Hill was promoted from assistant general manager of the Sparrows Point, Md., steel plant of Bethlehem Steel Co., to assistant to vice president, steel division at Bethlehem, Pa. **John S. Marsh** was advanced from engineer in the research department to assistant chief of research at Bethlehem, Pa. **John K. Killmer,** formerly metallurgical engineer, becomes chief metallurgist at Bethlehem, Pa. **C. Thompson Stott,** who was chief metallurgist at Sparrows Point plant, becomes assistant general manager of the Sparrows Point plant. **W. D. Poole** was promoted from assistant chief metallurgist at Sparrows Point plant to chief metallurgist of that plant. **J. J. Link** advances from assistant metallurgical supervisor, tin mills division, Sparrows Point plant, to assistant chief metallurgist at Sparrows Point plant.

Clarence R. Lohrey was named assistant general superintendent, in charge of expanded iron and steel production facilities at Kaiser Steel Corp., Fontana, Calif. Mr. Lohrey joined Kaiser Steel in 1947 and shortly became coke plant superintendent. In 1952 he was made division superintendent, iron and steel. Between 1923 and 1947, he served with Crucible Steel, Great Lakes Steel and Republic Steel. **Thomas G. Simison** was appointed assistant general superintendent, in charge of the diversified rolling mill operations at the Fontana works. Mr. Simison's previous experience, from 1926 to 1948, was with Carnegie-Illinois Steel, Inland Steel and Youngstown Sheet and Tube. He went to Kaiser Steel as assistant superintendent of the merchant mill. After becoming division superintendent of flat-rolled products, Mr. Simison was made responsible for all rolling mill operations. **Ernest F. Donatic** becomes assistant general superintendent, over maintenance services, utilities and transportation. Mr. Donatic went to Kaiser Steel in 1946 from service with Interstate Iron and Steel and Republic Steel, from 1923 to 1946. At the Fontana works, Mr. Donatic first acted as assistant and then superintendent of maintenance. In 1950 he was appointed division superintendent of services. **James P. Williams** was appointed assistant to the general superintendent and will be in charge of industrial and plant engineering, plant safety and traffic department functions. Mr. Williams' experience with Geneva Steel, U. S. Steel of Delaware and Carnegie-Illinois Steel dated from 1935 to 1945 when he joined Kaiser Steel as chief industrial engineer. His appointment to the position of division superintendent of engineering and planning followed in 1950. **Edward J. Duffy** was named to a new post as manager of raw materials development and will be responsible for operations of company-owned iron ore and coal mines in the West. Mr. Duffy held a number of supervisory positions at Carnegie-Illinois Steel from 1918 to 1942, then joining Kaiser Steel as blast furnace superintendent.

John A. Slenker has been named assistant vice president of operations of American Steel & Wire Division of U. S. Steel Corp., Cleveland, Ohio. Mr. Slenker went to his new position in Cleveland from Duluth, Minn., where he was district manager of operations for the wire division.

William G. Christy, until recently director of New York's Bureau of Smoke Control, has just announced that he has severed his connection with the city and opened an office as consulting engineer at 34 Park Row, New York, N. Y. Mr. Christy has had many years' experience in air pollution and smoke control work, as well as in power and heating plants. In 1925, when chairman, St. Louis Section, ASME, he helped organize the Citizens' Smoke Abatement League of St. Louis, Mo., and became its executive secretary.

Carl A. Boehme has been appointed assistant superintendent of the cold strip department in Campbell, Ohio, works of Youngstown Sheet and Tube Co. This is the department where he began as a laborer 17 years ago.

Chester C. Sanders was appointed supervisor of production and traffic at Armco Steel Corp.'s Zanesville, Ohio, division. Mr. Sanders succeeds **Ernest A. Stradley,** who recently retired.

JOHN S. MARSH

C. THOMPSON STOTT

C. R. LOHREY

JOHN A. SLENKER

Harold L. Farling has been named chief metallurgist of Republic Steel Corp.'s Cleveland, Ohio, district steel plant, succeeding **Thomas M. Chapman,** who has assumed new duties as contact metallurgist for the district's bar mills.

Elton W. Bruns has been appointed chief engineer of Stamco, Inc., New Bremen, Ohio after having served for 16 years as chief draftsman. **Richard E. Black** has been appointed sales and service representative. Mr. Black formerly served six years in the engineering department. **Myron L. Kuck,** with more than 11 years of service in the engineering department, has been appointed to the position of chief draftsman.

Thomas S. Walsh will become the new factory representative of Rust-Oleum Corp. for its complete line of rust-preventive products in metropolitan New York and the northern New Jersey trade area.

Eugene A. March was named chief metallurgist for Crucible's Sanderson-Halcomb works located in Syracuse, N. Y. Mr. March brings to his new position six years of metallurgical and operating experience gained at the Sanderson-Halcomb works. Previous to his new appointment, he was supervisor of metallurgical control at Sanderson-Halcomb. Before going with Crucible, he was associated with the Inland Steel Co. in Indiana Harbor, Ind., where he served in the metallurgical laboratory and open hearth departments.

Earl R. Fiene has been appointed manager of the Detroit, Mich., wholesale sales branch of the Alemite and Instrument division of Stewart-Warner Corp. Mr. Fiene succeeds **H. J. Howerth,** whose assistant he has been since March, 1951. Mr. Howerth, since 1935 assigned to car factory service promotion and sales responsibilities, has joined the distribution sales division at the corporation's general offices, Chicago, Ill.

GEORGE YOST, JR.

George Yost, Jr. has been appointed assistant general superintendent in charge of rolling and processing operations—a newly-established position at Armco Steel Corp., Ashland, Ky. **William Verity** will succeed Mr. Yost as assistant to the manager of the division. Mr. Verity had been serving as assistant supervisor of personal relations at the East Works at Middletown, Ohio.

WILLIAM VERITY

Gilbert C. Strege was named president of Baker-Lull Corp., Minneapolis, Minn. In confirming the appointment, the board of directors also approved the change in company name from the Lull Manufacturing Corp.

Samuel K. Hostetter, Jr., has been named sales manager of the Crocker-Wheeler Division of Elliott Co. at Ampere, N. J. Mr. Hostetter joined Elliott Co. in 1934. For the past ten years, Mr. Hostetter has served as manager of the Washington D. C., office.

SAMUEL K. HOSTETTER, JR.

C. L. Bayer was appointed assistant manager of operations for Great Lakes Steel Corp., Ecorse, Mich. **Paul Carnahan** was named vice president in charge of sales. **Charles P. Betz** has been named assistant vice president. Mr. Bayer has been assistant vice president in the operating department since 1948. First employed by Great Lakes in 1930 as an open hearth department superintendent, he was transferred in 1935 to the Weir-

Now! Make your own from the free air!

OXYGEN

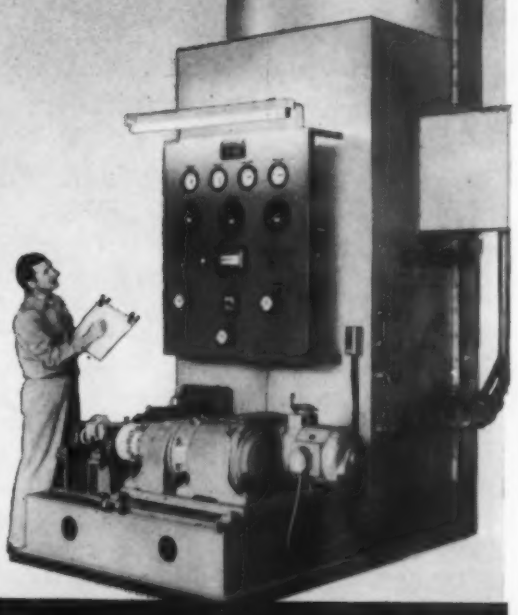
99.8% PURE

NITROGEN

99.8% PURE

... made simultaneously with ONE GENERATOR

Low cost invert gas—high-purity nitrogen in large quantities—*and* low cost high-purity oxygen—can now be made in the same generator. If you use oxygen—and use inert gases for annealing, steel making, heat treating, chemical manufacturing, etc., write us your requirements, and send for our CATALOG. *Air Products, Incorporated, Dept. P, Box 538, Allentown, Pa.*



***Air Products* is the largest manufacturer of oxygen-nitrogen generators in the U. S.**

Air Products

OXYGEN—NITROGEN—ARGON

GENERATORS

Specialists in Equipment for All Low-Temperature Processes

ton Steel Co., where he became steel works manager of the Weirton, W. Va., plant which like Great Lakes is a division of the National Steel Corp. He was returned to Great Lakes in 1948 as assistant vice president. Mr. Carnahan began his career with Great Lakes in 1933 as a blooming mill slab transfer operator. He was promoted to positions of successively increasing responsibility, including foreman, department superintendent and strip mill superintendent, and assistant general superintendent. He has been director of production since July, 1948. Mr. Betz has been general superintendent of blast furnace operations since last July. He joined Great Lakes in 1937 when construction began on the company's Zug Island coke plant, and became its first superintendent. He was appointed assistant manager of the coke plant in 1937.

Richard H. Bamford has been named assistant sales manager of the Rockbestos Products Corp., New Haven, Conn. Mr. Bamford has been district sales manager for Rockbestos in St. Louis, Mo., since 1949. Prior to that, he had been district sales manager in Detroit.

Lyle B. Schueler has been elected vice president in charge of sales of the Diamond Power Specialty Corp.,

LYLE B. SCHUELER

Lancaster, Ohio. Mr. Schueler has been sales manager of Diamond since the spring of 1950.

John E. Osmanski has been appointed supervisor of training for Crucible Steel Co. of America. Mr. Osmanski will direct the training of supervisors in the company's five plants and fuel division. Prior to joining Crucible, he was a member of the Pennsylvania State College faculty where as assistant professor of psychology he conducted management training programs for several industrial firms in Pittsburgh and Western Pennsylvania.

David I. Dilworth, Jr. was named to the newly created post of assistant director of metallurgy at Crucible Steel Co. of America. Mr. Dilworth moves up from Crucible's Sanderson-Halcomb Works located at Syracuse, N. Y., where he was chief metallurgist. In his new position, Mr. Dilworth will be located in the Oliver Building, Pittsburgh, Pa.

Robert Dickey has been named assistant to the sales manager of Dravo Corp. Engineering Works Division, Neville Island, Pittsburgh, Pa.

John Poast has been appointed superintendent of the newly established blast furnace department at the East

JOHN POAST

Works plant of Armco Steel Corp.'s Middletown, Ohio, division. **Edwin A. Kercsmar** will succeed him as superintendent of the blast furnace department at the Hamilton, Ohio, plant. Mr. Poast has served as superintendent of the blast furnace department since 1948. Mr. Kercsmar was serving as assistant superintendent of the blast furnace department.

EDWIN A. KERCSMAR

A. Stewart Murray has been appointed chief engineer of SKF Industries, Inc., Philadelphia, Pa. Mr. Murray has served in various engineering capacities in the industrial manufucturing field for 18 years. Mr. Murray will make his headquarters at SKF's main plant in Philadelphia.

26″ STRUCTURAL MILL

BUILT BY **MORGAN** *Engineering*

DESIGNERS • MANUFACTURERS • CONTRACTORS

BLOOMING MILLS • PLATE MILLS • STRUCTURAL MILLS

ELECTRIC TRAVELING CRANES • CHARGING MACHINES

INGOT STRIPPING MACHINES • SOAKING PIT CRANES

ELECTRIC WELDED FABRICATION • LADLE CRANES

STEAM HAMMERS • STEAM HYDRAULIC FORGING PRESSES

SPECIAL MACHINERY FOR STEEL MILLS

THE MORGAN ENGINEERING CO.

ALLIANCE, OHIO PITTSBURGH—1420 OLIVER BUILDING

Illustrated is a 26″ Three-High Structural Mill, consisting of one 26″ Three-High Pinion Stand connected to two Three-High Roll Stands and one Two-High Pinion Stand connected to one Two-High Finishing Stand.

For serving this mill, there was furnished four Traveling and Tilting Tables and four Traveling Trailing Tables.

Your inquiries for mill equipment will be appreciated.

T. J. Marshall and **K. W. Macdonald** have been appointed General Electric Construction Materials district representatives. Mr. Marshall has been with General Electric since 1935. He has been assigned to handle accessory equipment products in the north central district. His office will be at 5726 West 51st Street, Chicago, Ill. Mr. Macdonald will handle the full line of Construction Materials in the Columbus trading area of the division's Great Lakes district. His office will temporarily be at 925 Euclid Avenue, Cleveland, Ohio.

Harold W. Lownie, Jr., has been appointed to a supervisory post in Battelle Institute's process metallurgy laboratories. Mr. Lownie replaces **C. T. Greenidge,** a veteran member of the Battelle staff, who has been appointed an assistant to the director to serve as a liaison officer between research and executive activities. In his new position, Lownie will supervise much of Battelle's research related to foundry practice and ore reduction.

H. L. Cahan has been appointed district representative for General Electric's Construction Materials Division. In his new assignment, he will be responsible for the wire and cable department's products in the Los Angeles area with offices at 3000 East 46th Street, Los Angeles, Calif.

William Hagel and **Maurice P. Sieger** have been appointed to fill vacancies on the board of directors of the United Engineering and Foundry Co. Mr. Hagel is vice president in charge of sales for the company. He is a graduate of Carnegie Institute of Technology and since

WILLIAM HAGEL

joining the company in 1917 has successively held the position of estimator, chief estimator, assistant to sales manager, assistant sales manager, manager machinery sales, and manager of sales. In 1946 he was elected vice president in charge of sales. Mr. Hagel also serves as vice president, director and member of the executive committee of Adamson United Co., Akron, Ohio and vice president in charge of sales, director and member of the executive committee of Lobdell United Co., Wilmington, Del. Mr. Sieger, vice president and senior engineer, also attended Carnegie Institute of Technology. He started with United in 1922 as a mechanical engineer and became assistant chief and chief engineer

M. P. SIEGER

successively and was elected to the position of vice president in charge of engineering on July 25, 1944. Mr. Sieger also serves on the board of directors of Stedman Foundry and Machine Co., Inc., Aurora, Ind.

C. Brenton Cook of Elwell-Parker Electric Co., Cleveland, Ohio, has announced his retirement. His departure from company activities marks the end of a career which covered a period from 1914 until January, 1953. After an association with the Allis-Chalmers Mfg. Co., Mr. Cook joined the Elwell-Parker Electric Co. in 1914 as Cleveland district salesman. He established the sales, advertising and export departments, has been manager of sales promotion and advertising since 1915, was named export manager in 1921, and was named vice president and a director of the company in 1942.

O. B. Wilson has been named industrial instruments sales manager for the Industrial Division of Minneapolis-Honeywell Regulator Co., Philadelphia, Pa. Mr. Wilson joined Honeywell in 1923. He was industrial manager in Chicago, New York and other offices. In 1948 he was made industrial manager for the eastern sales region. Early last year Mr. Wilson was named field sales manager for the Industrial Division.

Andrew C. Perrin was named to the newly created post of west coast district sales manager of the Reliance Electric & Engineering Co. A sales application engineer operating out of the company's Chicago, Ill., office for the past six years, Mr. Perrin already has assumed his new assignment, making his headquarters in San Francisco, Calif.

Ralph N. Fitzpatrick was appointed district manager of the Cleveland, Ohio, office of Electro Metallurgical Co., a division of Union Carbide and Carbon Corp. Mr. Fitzpatrick succeeds **E. E. Wright,** who has reached retirement after almost 35 years' service with the corporation, and who will carry on as sales consultant in the Cleveland area.

J. Edward House, Jr., was appointed to the Pittsburgh, Pa., sales staff of the Reliance Electric & Engineering Co. In his new post Mr. House replaces **Keith E. Carter,** sales application engineer who has been transferred to the company's sales office in Chicago, Ill.

Harold Cope, general superintendent of American Steel & Wire Division's Steel & Wire works in Donora,

HAROLD COPE

Pa., has been named manager of operations of the division's Duluth, Minn., district.

Edward C. Kent has been appointed manager of industrial relations for Acme Steel Co.'s plants at Archer Avenue in Chicago and Riverdale, Ill., and Racine, Wisc. Mr. Kent joined Acme Steel in November, 1949 as assistant director of industrial relations after serving as general counsel of industrial relations at Victor Manufacturing and Gasket Co., Chicago, and as assistant director of labor relations of the Sherwin-Williams Co., Cleveland, Ohio.

F. H. Webster has been appointed manager of Hyatt Bearing Division, General Motors Corp.'s western division sales office in Chicago, Ill. Mr. Webster succeeds **C. L. Newby** who has retired after 34 years of service with Hyatt in several capacities. Mr. Webster prior to this appointment was assistant manager of Hyatt's western sales division in Chicago. He was originally with the Pacific Coast office and has served on various sales and engineering assignments there, the southwest and the Chicago territory for the past 27 years.

Charles Allen, Jr., chairman of the board of the Colorado Fuel and Iron Corp., was named chairman of the board of John A. Roebling's Sons Corp., a new Colorado Fuel and Iron subsidiary which has acquired the 112-year old firm of John A. Roebling's Sons Co., Trenton, N. J. **A. F. Franz,** president of the Colorado Fuel and Iron Corp. was named president of John A. Roebling's Sons Corp. **Charles Roebling Tyson** was named executive vice president of John A. Roebling's Sons Corp. Mr. Tyson was president of Roebling's Sons Co. before its acquisition by Colorado Fuel and Iron. He started with the company in 1935, worked in a number of departments including the open hearth and wire mills, and became secretary-treasurer in 1940. In September, 1944, he became president.

W. Paul Scholler, formerly with the engineering department of the United States Steel Corp. at their Homestead, Pa., works has been appointed as service engineer for the Geo. P. Reintjes Co. at their Pittsburgh, Pa., office. Mr. Scholler's many years of experience in open hearth furnace designing will be of valuable assistance to the many steel companies in this area.

E. Topanelian, Jr. has been appointed director of engineering, for Gulf Research and Development Co., Pittsburgh, Pa. **Bruce R. Walsh** was named assistant director of engineering. **J. Edward Taylor,** formerly a member of the product development and product engineering department of the Gulf companies, has been transferred to the research department as director of automotive engineering, with **Charles R. Butler** and **R. L. Kirkpatrick** as assistants to the director.

D. Pat Cromwell was appointed manager of blast furnaces and coke ovens of Ford Motor Co.'s Rouge plant, Dearborn, Mich. Formerly assistant manager, Mr. Cromwell succeeds **Dan L. Newkirk,** who has retired after more than 34 years with the company. Mr. Newkirk, a native of Detroit, joined Ford in 1918 as an engineer in the power and construction department. He advanced from millwright foreman to supervisor of blast furnaces and in 1948 became manager of the Rouge blast furnaces and coke ovens. Mr. Cromwell joined Ford Motor Co. in 1949 after serving as superintendent of blast furnaces of the Campbell and Hubbard, Ohio, plants of Youngstown Sheet and Tube Co.

D. W. Lloyd has been named general superintendent of the Indiana Harbor, Ind., works of Youngstown Sheet and Tube Co. Mr. Lloyd has been serving, since

D. W. LLOYD

1947, as general superintendent of the Brier Hill works in Youngstown, Ohio. He has been with Youngstown Sheet and Tube since 1935, prior to this he had been with Carnegie-Illinois Steel Corp. and Republic Steel

Corp. Mr. Lloyd is on the AISE Board of Directors for 1953.

C. L. Heater, vice president, will head the newly formed transportation equipment division of American Steel Foundries, Chicago, Ill. **G. H. Snyder,** vice president, will assist Mr. Heater in a staff capacity. **C. E. Grigsby** was named vice president in charge of sales. **E. A. Walcher, Jr,** becomes vice president in charge of manufacturing and **R. B. Cottrell** will be chief mechanical engineer. **R. D. Brizzolara,** vice president, who now heads the Elmes & King Division, will also be in charge of the newly organized Hammond Division, with **E. L. Krejci** as general manager, **R. W. Clyne** as sales manager, **M. W. Kraegel** as works manager, Hammond plant, and **C. E. Tack** as product engineering manager. **M. J. Allen** will become director of personnel and public relations, and **E. J. Walsh** will continue as manager of industrial relations.

Wade B. Houk was named general superintendent of American Steel & Wire Division of U. S. Steel

WADE B. HOUK

Corp.'s South works at Worcester, Mass. Mr. Houk of American Steel & Wire Division of U. S. Steel Corp.'s South works at Worcester, Mass. Mr. Houk has been division superintendent of South works' wire mills.

E. C. Brekelbaum, formerly vice president and executive engineer of Harnischfeger Corp., Milwaukee, Wisc., has been appointed director of methods of Thew Shovel Co., Lorain, Ohio. The scope of this newly created post includes any operation within the engineering and manufacturing departments of the company.

O. C. Callow, specialty production manager of Freyn Engineering Department of Koppers Co., Inc., Chicago, Ill., after 25 years of service, has retired to his home in St. Petersburg, Fla. Mr. Callow joined Freyn Engineering in 1927 as assistant electrical engineer, and was shortly promoted to electrical engineer. In 1940, he took over the duties of purchasing agent and in 1950 was made manager of the specialty production section. Before joining Freyn, Mr. Callow was electrical superintendent of Trumbull Cliffs Furnace Co., Warren, Ohio, now part of Republic Steel Corp., assistant electrical engineer of Steel and Tube Co. of America, Indiana Harbor, Ind., now Youngstown Sheet and Tube Co., and construction engineer for Westinghouse Electric Corp.

Umbert F. Corsini was made general superintendent of the steel and wire works of the American Steel & Wire Division of U. S. Steel Corp., in Donora, Pa. Mr. Corsini was general superintendent of American Steel & Wire's South works in Worcester, Mass.

UMBERT F. CORSINI

R. M. Brown has been named purchasing agent, iron and steel scrap for U. S. Steel Corp., Pittsburgh, Pa. **W. W. Crawford** becomes purchasing agent, electrical and mechanical equipment. **R. F. Dyson** was appointed assistant purchasing agent, electrical and mechanical equipment. **R. D. Crowley** is now purchasing agent, construction materials and services. **R. J. MacKenzie** was made assistant purchasing agent, construction materials and services.

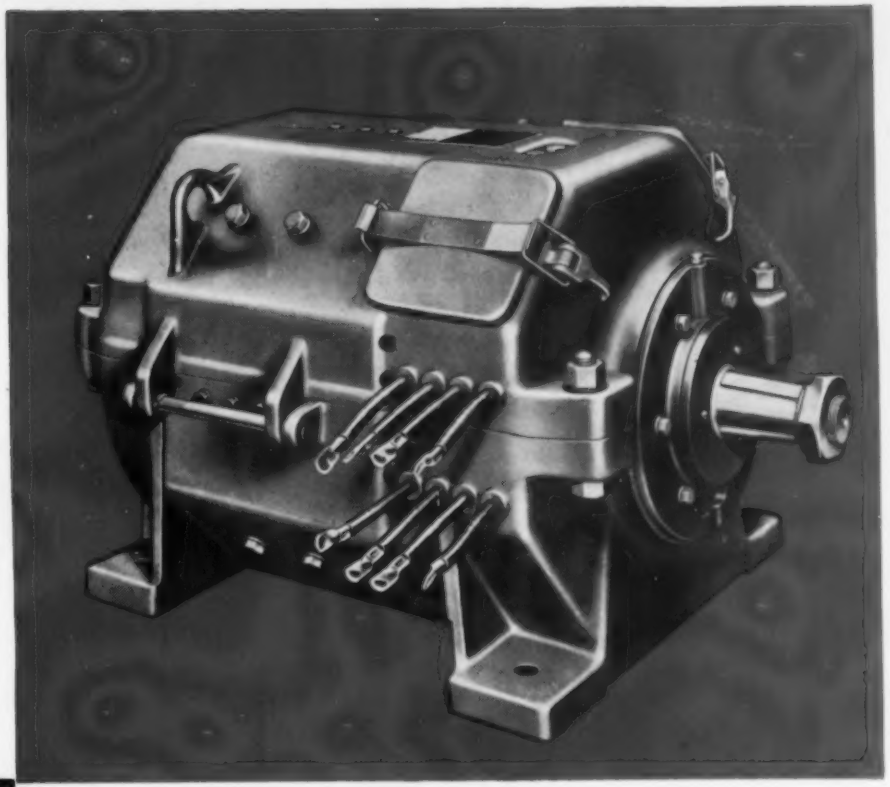
Carter H. Gray has been appointed assistant superintendent of the continuous weld pipe mill at Kaiser Steel Corp.'s Fontana, Calif., works. **Charles S. McClure,** formerly general foreman of the continuous weld finishing department, was appointed general foreman of the finishing and galvanizing department of the continuous weld pipe mill.

George Breyer, formerly chief metallurgist of Crucible Steel Co. of America's Midland, Pa., works, has been appointed metallurgical service engineer for the Detroit, Mich., area.

Frank Scarr, until now assistant controller of Kaiser Steel Corp., has been promoted to the position of assistant to the vice president in charge of operations at Fontana, Calif.

Richard J. Skillman has been named purchasing agent of General Refractories Co. Mr. Skillman succeeds

If it's a heavy duty drive...



WHERE TOUGHNESS COUNTS
is on jobs like this — one of four 200-hp Elliott Crocker-Wheeler Mill Motors driving the roll tables on a slabbing mill. These motors with their associated equipment are designed to accelerate the 24 rolls per table from standstill to rated speed in from 2 to 2.8 seconds. The unretouched photo graphically shows the conditions under which these motors operate.

ELLIOTT *Crocker-Wheeler* 600 *Series* MILL MOTOR

Put it up against the toughest service in mill or crane — give it punishing overloads, constant stopping and starting, reversing strains, heat, dust, fumes, or any other grief. This is the motor that will take it and come up asking for more.

Adaptable, too. The standard 600 Series motor can be modified for use as a separately forced-ventilated type, and if required, as a protected self-ventilated type, also if required can be supplied with built-in back gear unit. In every case, servicing is fundamentally simple, for the cast-steel split frame can be opened to admit of free access to the interior.

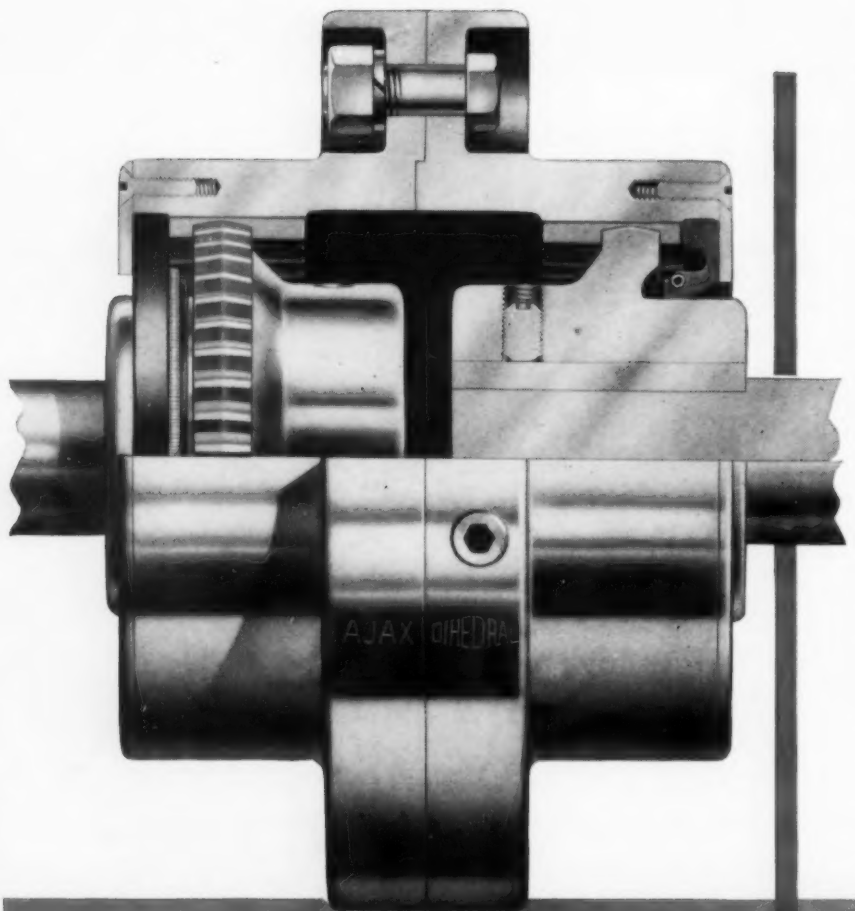
For details, ask your local Elliott field engineer, or write for the Mill Motor Bulletin to Elliott Company, Jeannette, Pa.

ELLIOTT Company

CROCKER-WHEELER DIVISION

W3-3

AJAX DIHEDRAL
FLEXIBLE COUPLINGS



New Couplings Engineers Have Been Waiting for

● Thousands of hours, and dollars are being saved by original equipment manufacturers, installation and maintenance men because of the ability of Ajax Dihedral Couplings to handle misalignment heretofore considered excessive.

They simplify machine design, cut installation time and reduce maintenance costs.

New exclusive Ajax Dihedral tooth shape provides for maximum misalignment with tooth clearance (backlash) kept to oil film requirements. 30 degree involute splines provide strong basic tooth form. Positive seals keep lubrication in and dirt out.

AJAX DIHEDRAL COUPLINGS PROVIDE FOR AND PROTECT AGAINST MISALIGNMENT

Cross-section photograph shows basic design of Ajax Dihedral Couplings.

Stock couplings are built to handle misalignment up to 4°. Teeth can be cut to handle greater misalignment but each job must be engineered. Be up-to-date on this latest development in flexible couplings,— write for Ajax Bulletin

AJAX FLEXIBLE COUPLING COMPANY INC.
WESTFIELD, N. Y.

John A. Ross who has been appointed director of purchases. Mr. Ross, who has been purchasing agent since 1919, joined Wynn Fire Brick Co. in 1906. The company was subsequently purchased by General Refractories Co. Mr. Skillman, who has been assistant purchasing agent since 1946, joined the company in 1936.

Gordon A. Zwissler, until now superintendent of Kaiser Steel Corp's. blooming and structural mills and

GORDON A. ZWISSLER

the auxiliary soaking pits and conditioning yards operations, at Fontana, Calif., has been advanced to the position of division superintendent, rolling.

John V. Eakin, who has been with Fawick Airflex Division, Federal Fawick Corp. since 1943, has been appointed assistant general manager. He was formerly sales manager and southwestern district manager. Mr. Eakin will be located in Cleveland, Ohio. **Clement Reeves** has been named sales manager to succeed Mr. Eakin. Working with Mr. Reeves will be **K. R. Spelman,** who becomes assistant sales manager. Mr. Spelman has been a sales engineer since he went with Fawick in 1945. **J. S. Walsh,** formerly chief engineer and with the company since 1944, becomes director of engineering and service. **W. A. Franck,** who was design and development engineer, and with the company since 1943, now becomes chief engineer.

John L. Campbell was appointed vice president of sales for Ohio Steel Foundry Co., Lima, Ohio. Mr. Campbell had been serving as general manager of Lima plant sales. **T. H. Harvey,** who formerly was vice president of sales, became senior vice president.

Robert H. Olsen, division manager of works accounting at Kaiser Steel Corp., Fontana, Calif., has been appointed assistant controller.

G. M. Wallace, manager of Bailey Meter Co.'s Denver, Colo., district, has been appointed an assistant sales manager with headquarters in Cleveland, Ohio. He will supervise the sale of meters and control equipment to the process industries.

Carl E. Schmitz has recently been appointed vice president in charge of sales for Crane Packing Co., Chicago, Ill. He formerly held the position of vice president and director of engineering.

James M. White has been elected vice president in charge of manufacturing of the American Car and Foundry Co. succeeding **Robert W. Ward,** vice president, who has retired after 42 years of service.

Dr. Cyril G. Veinott, nationally renowned electric motor design engineer, inventor and author, has joined the Reliance Electric & Engineering Co., Cleveland, Ohio, as consulting engineer on a-c machinery. Dr. Veinott comes to the Reliance organization from the Westinghouse Electric Corp. where, for the past 25 years, he has been engaged chiefly in small motor engineering at this company's plants in Springfield, Mass., and Lima, Ohio.

R. E. Buckholdt, formerly employed by Salem Engineering Division of Salem-Brosius, Inc. and Salem Engineering Co. since 1934, is presently associated with Kendall Engineering Co., at Alliance, Ohio.

C. A. MacIlvaine was named assistant controller of Kaiser Steel Corp., Oakland, Calif. Mr. MacIlvaine has served as division manager, general office accounting, in the company's Oakland headquarters for the past year and formerly was office procedures and service manager at the Fontana, Calif. plant.

Reynold C. MacDonald was appointed superintendent of the blooming and structural mills at Kaiser Steel Corp., Fontana, Calif. Mr. MacDonald, formerly as-

R. C. MACDONALD

sistant superintendent of the company's merchant and skelp mills, will in addition be responsible for conditioning yard and crane department functions.

Dr. Robert F. Stoops has joined the advance development section of the Carboloy Department of General Electric Co., Detroit Mich. He was formerly a research engineer with the Harbison Walker Refractories

Co. in Pittsburgh, Pa. **Anthony D. Cortese** has joined the design and application section. He will specialize in magnetic applications. **Frank B. Nuelle** has been transferred to the Detroit plant from the Carboloy Department's Schenectady operation. He will be assigned to the administrative engineering section.

Arnold I. Thorsen, works manager, Allis-Chalmers Manufacturing Co. Norwood, Ohio, works, has been appointed assistant director of manufacturing of the company's general machinery division, at Milwaukee, Wisc. **J. F. Costigan,** assistant works manager at Norwood, has been named the new works manager replacing Mr. Thorsen.

Fred R. Fielding was named chief engineer of the Buffalo, N. Y. district of Republic Steel Corp. Mr. Fielding has been with Republic for 28 years. He had been Republic's Buffalo district assistant chief engineer since April 1945.

Harold D. Newell was named as consulting metallurgist and **John J. B. Rutherford** was appointed chief metallurgist of the Tubular Products Division of Babcock & Wilcox Co., Beaver Falls, Pa. Mr. Newell has been chief metallurgist since 1927. Mr. Rutherford, who has been assistant chief metallurgist, will now be in charge of the research section of the laboratory, process and product development and customer metallurgical service.

J. S. Roscoe has been appointed executive vice president in charge of business administration at Lincoln Electric Co., Cleveland, Ohio. **William Irrgang,** who was appointed executive vice president in October 1951, is in charge of all manufacturing.

Richard F. Thuma has been appointed superintendent of the tools and maintenance section in the Allis-Chalmers West Allis, Wisc., works.

C. W. Kalchthaler was appointed assistant to the general sales manager of Hyatt Bearings Division, General Motors Corp. with headquarters at Harrison, N. J. Mr. Kalchthaler has been assistant manager of the Hyatt Motor Division sales office in Detroit, Mich.

Adam Zandel was named executive engineer in charge of administration of the engineering department at the Loewy Construction Co., Inc., subsidiary of Hydropress, Inc., New York, N. Y.

Jerry G. Rizzo has been appointed manager of the export department of the Elliott Co. His offices are located at 271 Church Street, New York, N. Y.

Albert H. Lindsay has been appointed manager of the newly expanded service department of the Nickel Cadmium Battery Corp. with offices at 100 Park Avenue, New York, N. Y. Mr. Lindsay joined Nickel Cadmium organization in January 1948. His background includes fifteen years as a service and sales engineer with the Edison Storage Battery division of Thomas A. Edison, Inc.

Obituaries

George G. Thorp, 84, former president of the old Illinois Steel Co., died January 19. Mr. Thorp supervised the design, construction and operation of U. S. Steel Corp.'s Gary steel works, in 1906. Born June 29, 1868 in Pittsburgh, Pa., he was educated at the University of Wisconsin and joined Illinois Steel as a testing engineer in 1892. He became general superintendent of the company's Joliet, Ill., works in 1899, and the following year supervised construction and operation of steel mills in Clairton, Pa., before he returned to Chicago in 1905. In 1905, he was appointed vice president of Illinois Steel Co. and became president in 1932. He retired in 1935 when the Illinois company and the old Carnegie Steel Co. were merged as a U. S. Steel subsidiary.

George William Abel, 64, general superintendent of the steel plant at Indiana Harbor, Ind., works of Youngstown Sheet and Tube Co., died January 12. During summers Mr. Abel worked at South works of Carnegie Steel Co. and joined that company after finishing school. He advanced to superintendent of the rolling mills and received a 25-year emblem before he left there to join Youngstown Sheet and Tube Co. in 1929 as superintendent of the rolling mills. He became assistant general superintendent of the steel plant in 1942 and general superintendent in 1944.

Dr. Charles Holmes Herty, Jr., 56 assistant to the vice president of Bethlehem Steel Co.'s steel division, died suddenly January 17.

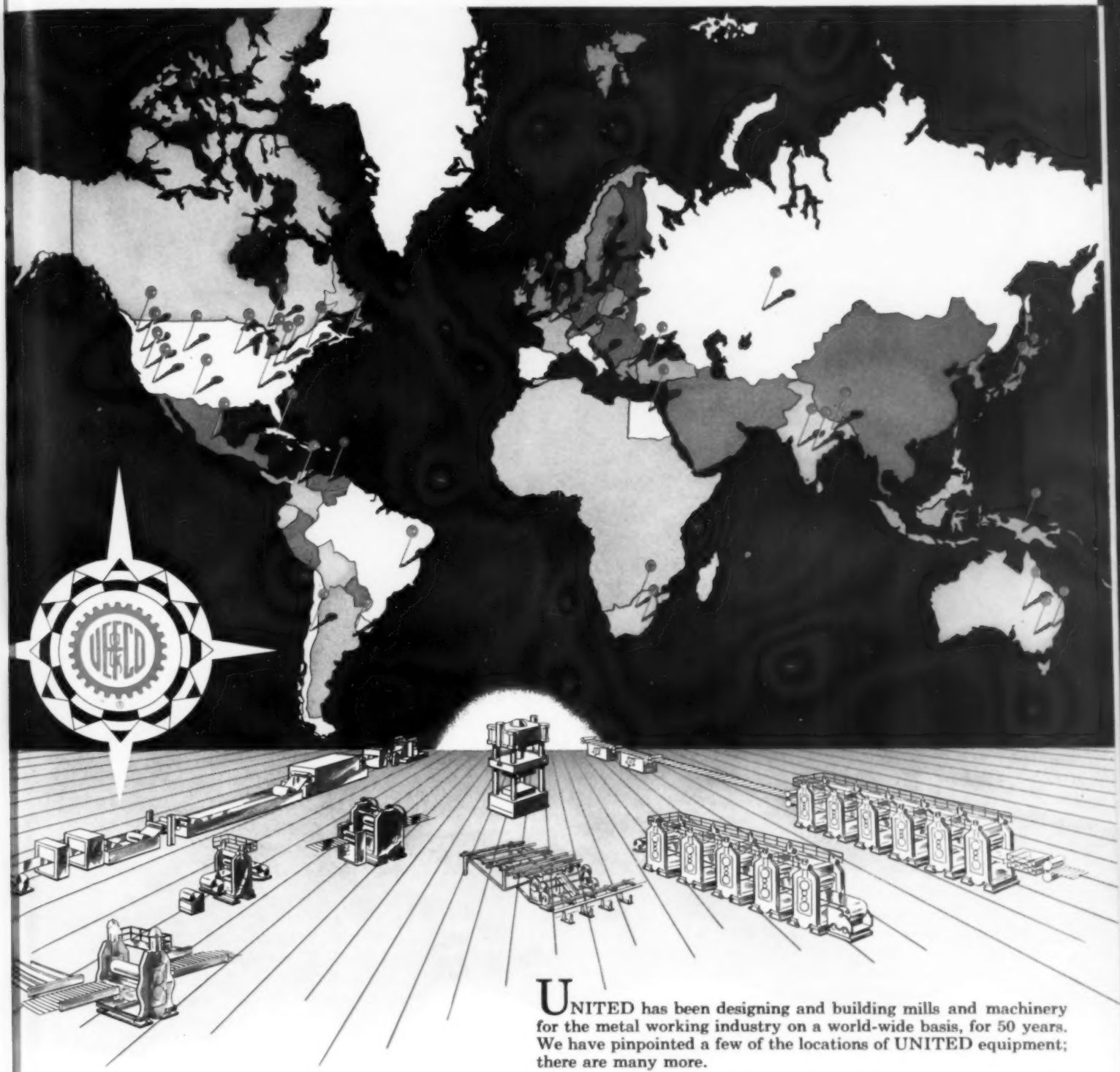
Frank M. Mason, 42, vice president of U. S. Electrical Motors, Inc., died December 27. Mr. Mason was general manager of the company's Atlantic plant in Milford, Conn.

Carl D. Fischer, Jr., 71, president and general manager of Wapakoneta Machine Co., Wapakoneta, Ohio, died December 28 at his home in Wapakoneta, Ohio, following a two-year illness.

Henry J. Sandblade, consulting engineer and vice president of Thomas Flexible Coupling Co., Warren, Pa., died January 8. Mr. Sandblade had been connected with the Thomas Flexible Coupling Co. for the past 32 years.

UNITED

CAN SERVE YOU . . . NO MATTER WHERE IN THE WORLD YOU ARE



UNITED has been designing and building mills and machinery for the metal working industry on a world-wide basis, for 50 years. We have pinpointed a few of the locations of UNITED equipment; there are many more.

Inquiries concerning modern rolling mills and metal processing equipment are solicited from mill operators everywhere; for no matter where in the world you are—at home or abroad—UNITED can serve you.

Write or wire us direct. Cable address: UNITED PITTSBURGH.

Designers and Builders of Ferrous and Non-Ferrous Rolling Mills, Mill Rolls, Auxiliary Mill and Processing Equipment, Presses and other heavy machinery. *Manufacturers of* Iron, Nodular Iron and Steel Castings and Weldments.

UNITED

ENGINEERING AND FOUNDRY COMPANY

Pittsburgh, Pennsylvania

Plants at

PITTSBURGH • VANDERGRIFT • NEW CASTLE

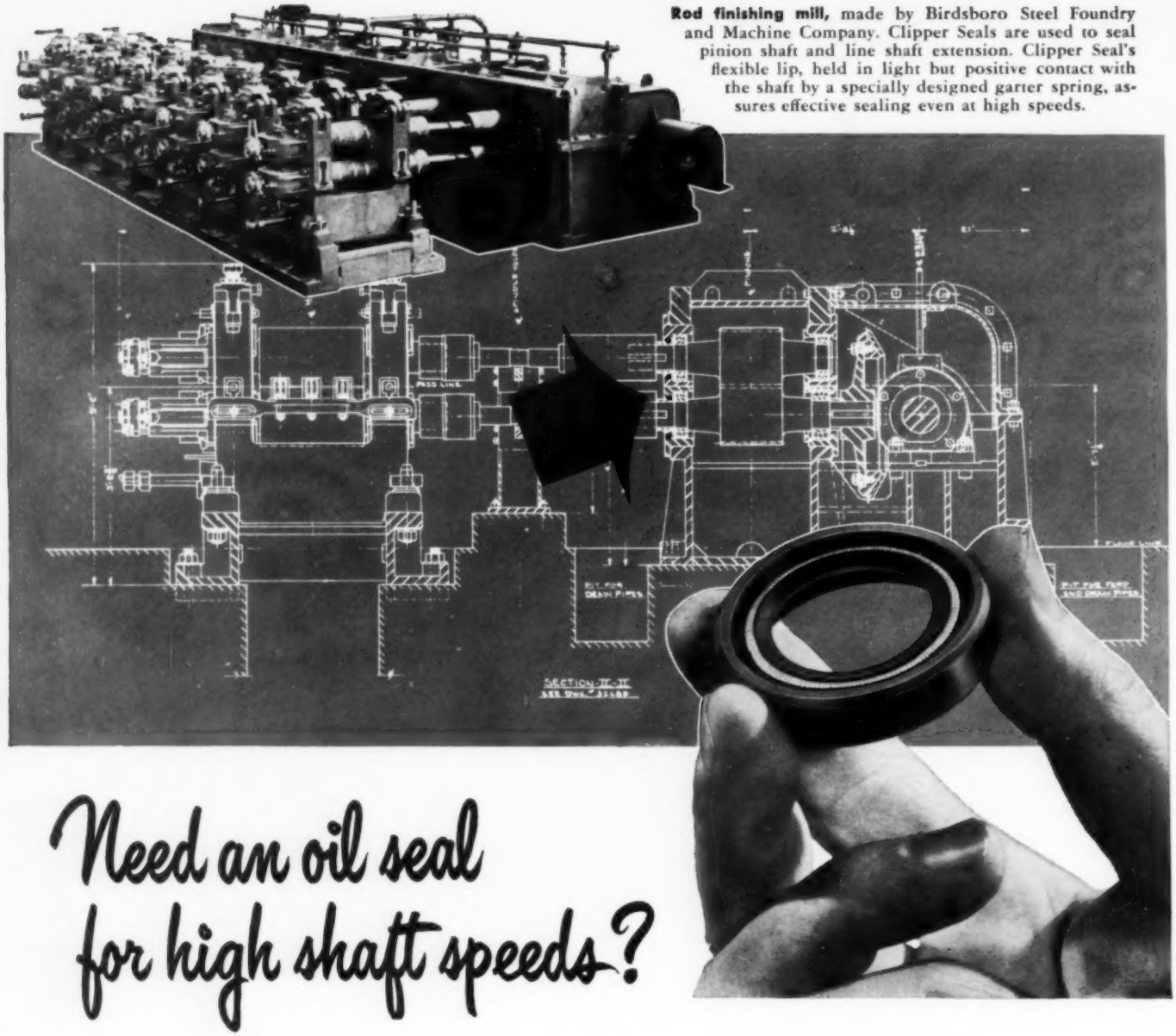
YOUNGSTOWN • CANTON

SUBSIDIARIES:

Adamson United Company, Akron, Ohio

Lobdell United Company, Wilmington, Delaware

Stedman Foundry and Machine Company, Inc., Aurora, Indiana



Rod finishing mill, made by Birdsboro Steel Foundry and Machine Company. Clipper Seals are used to seal pinion shaft and line shaft extension. Clipper Seal's flexible lip, held in light but positive contact with the shaft by a specially designed garter spring, assures effective sealing even at high speeds.

Need an oil seal for high shaft speeds?

Birdsboro chose Clipper Seals

The Birdsboro 8-stand finishing train shown above is expected to operate around the clock, day in and day out. And since it is to be part of a large, high-speed, steel rod producing unit, Birdsboro designed it to be as maintenance-free as possible.

In order to minimize down time, particular attention was paid to bearing design and lubrication. The mill stands are equipped with open, water-lubricated bearings. Because of high shaft speeds, bearings in the combination spiral bevel gear reduction and pinion stand are anti-friction in type, lubricated with circulating oil, and sealed with Clipper Seals.

Birdsboro engineers chose Clipper Seals for this application because of their outstanding ability to withstand the heat of friction generated by high shaft speeds . . . and their ability to make a tight and lasting seal against the circulating bearing lubricant.

Still other reasons for Birdsboro's preference for Clipper Seals: They are precision-molded, compact in design, and exceptionally easy to install. They may be removed and replaced without impairing their sealing efficiency. And because of their unique design, Clipper Seals cause a minimum of shaft wear.

Precision-molded Clipper Seals are made in a variety of designs to meet almost any sealing condition. They are available in split and endless types, with a choice of heel and lip combinations for various services. For details, write for Brochure PK-46A. Address, Johns-Manville, Box 60, New York 16, N. Y. In Canada, 199 Bay Street, Toronto 1, Ontario.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville CLIPPER SEALS

Publication Service...

FEBRUARY, 1953

You Can Obtain...

... any of the bulletins reviewed in the Publication Service of the IRON AND STEEL ENGINEER without obligation or cost. Simply circle the desired item numbers on one of the prepaid postal cards and mail. The requests will be forwarded to the manufacturers involved who will send the bulletins to you.

(1) Wire Rope Sling Handbook

A new 64-page handbook on Leschen slings and fittings is now available. It is printed in a handy pocket size—for convenient reference on the job or in plant offices. It contains more than 100 illustrations, showing standard wire rope slings, grommet slings and multiple part slings, the latter including flat-laced, hand-braided slings. Charts show correct calculations for determining the size of slings required, and correct sling angles in relation to loads. The new line of red-strand 8-part braided slings is featured in the handbook, along with the money-saving pin-lock thimbles. (FS-52) A. Leschen & Sons Rope Co.

(2) What Makes A Magnet?

A new chart, "What Makes A Magnet?," describing the natural forces causing magnetism and how they are harnessed to create a useful tool for industry and the home, is being offered free. The chart is made up of diagrams and drawings with explanatory captions. The chart explains the potential magnetic forces found in a ferromagnetic atom. How these natural forces are organized by the application of an external magnetic field is then concisely presented. Whereas soft magnetic materials such as iron retain only a little of such induced magnetism, hard substances such as Alnico, of which Eriez magnetic separators are made, hold on to most of their newly obtained force permanently. Eriez Manufacturing Co.

(3) Stops Rust!

Is the title of a general catalog just released. The new catalog, featuring 73 color chips of Rust-Oleum products, includes complete instructions for surface preparation and application of primers, short oil type, long oil type, machinery and implement finishes, chemical and heat resistant types, sealers, thinning oils, and floor and masonry coatings. Colorful "in use" illustrations show how each type of these products are used. Two pages are devoted to questions and answers concerning surface preparation and applications of Rust-Oleum products. (252) Rust-Oleum Corp.

(4) Blast Cleaning Hot Strip Steel

Descaling hot-rolled steel strip at high speeds and low cost by means of airless blasting is the subject of a new bulletin just published. Detailed descriptions of the airless blasting equipment and its operation at two prominent steel mills are presented. Both are illustrated. The bulletin describes how airless blasting eliminates scale breaking, permits descaling at production line speeds of from 190 to more than 400 fpm (depending upon the number of abrasive throwing units used), reduces the use of pickling acid, reduces manpower and space requirements, and saves metal (since airless blasting removes scale only). (894) American Wheelabrator and Equipment Corp.

(5) Electroplating Complex Shapes

A new bulletin points out that the more modern plating plants, making the utmost use of chemistry, electrochemistry, plating engineering and plating "know how," are successfully electroplating nickel on large, complex equipment up to 700 sq ft in area. For handling corrosive materials, heavy electroplated metallic coatings will supplement, or substitute for, clad metals, wrought metals and alloys not only as a means of conservation but, in many cases, as an economic measure. This is particularly true where a large number of pieces of the same size and shape are required. Design factors, welds, preparation and plating methods are discussed. International Nickel Co., Inc.

(6) Boiler Control

A new bulletin illustrates and describes the new Copes-Vulcan boiler control with instrumentation by Taylor. Includes combustion, feed water, boiler steam temperature and soot blower controls. Standard or miniature instruments and conventional, console or graphic panels. (1007) Copes-Vulcan Division, Continental Foundry and Machine Co.

(7) Soot Blowers

Just published is a bulletin which discusses fifteen central station installations of Vulcan automatic-sequential soot blower systems. Power and reheat boilers with capacities to 1,370,000 lb per hr, pressures to 1925 psi and temperatures to 1055 F are included. Blowing medium is steam or air, and units are power-driven by air or electric motor. (1004) Copes-Vulcan Division, Continental Foundry and Machine Co.

(8) Controlled Draft Fans

Induced draft bifurcator fans, said to provide controlled draft for boilers and furnaces at all times, are the subject of a new catalog just issued. The induced draft bifurcator is a motor driven axial-flow fan in a divided housing. Motor is in an isolated chamber around which flue gases are bypassed, so that the motor always remains clean, easily accessible and well within safe temperature limitations. The cost of an induced draft bifurcator fan is usually only a fraction of the cost of a suitable brick or steel stack, according to the manufacturer. Catalog contains illustrations, specifications and dimensions of these fans in 24 sizes, for high pressure boilers delivering up to 60,000 lb of steam per hr and for low pressure boilers rated up to 190,000 EDR. (DB-32-52) De-Bothezat Fans Division, American Machine and Metsl, Inc.

(9) "Efficient Pickling . . .

. . . with 'Rodine' " is the title of a new bulletin available to you. This is the latest edition of a standard reference work on pickling. Many sections have been revised, and much new information, with photographs, is included. Although pickling is an essential operation in the steel industry, it developed along empirical rather than the scientific lines that characterized the industry as a whole.

With the development of the selective inhibitor "Rodine" pickling entered a new era. (660A) American Chemical Paint Co.

(10) Wire Thread Inserts

Suggested ways to improve products, reduce production cost and increase customer satisfaction by using stainless steel wire thread inserts in tapped holes fill a new eight-page booklet just prepared. Text discusses design, production, marketing and maintenance advantages offered by this method of thread protection. Photographs show a variety of products so protected in the fields of internal combustion engines, heavy assemblies such as industrial furnaces, and the housings of impact tools. One page is devoted to a check-list, of interest to sales and production management, reciting the varied savings possible when design is based on assembly with helical thread inserts. (660) Heli-Coil Corp.

(11) Helical Gear Drives

Helical gear drives — their advantages, fields of application and correct selection — are discussed in a new, illustrated 16-page book just released. Full-page cross-sectional views show in detail the design and construction features of both the double and triple reduction types. Installation photographs picture typical installations. All factors governing correct selection are described in detail. The right drive for any application can be chosen readily, because horsepower ratings for all drives, in all ratios, for various input speeds, are shown in tabular form.

Load classes for 170 types of machines, arranged alphabetically from agitators to windlasses, are tabulated. Other tables give the maximum overhung loads for drives of various sizes. Principal dimensions of the various drives are shown. Link-Belt helical gear drives are made in a range of sizes for capacities from fractional to over 100 hp and ratios up to approximately 300 to 1. (2451) Link-Belt Co.

(12) Roller Hearth Furnaces

A new, illustrated bulletin on roller hearth furnaces has just been released. Featuring the three principal design types — controlled atmosphere, direct-fired convection heated — the bulletin describes typical process applications in both the ferrous and nonferrous fields. Related prepared gas atmosphere generators are shown and a handy chart of prepared atmosphere compositions and applications is included for reference. (SC-160) Surface Combustion Corp.

(13) Tapecoat Guide

A new illustrated brochure designed to help solve corrosion problems has just been released. Based on the company's experience in serving the gas and oil fields, transportation and communication, water and sewage and chemical and industrial applications, the brochure presents practical suggestions to combat corrosion. It includes details on how and where coal tar protection can be used to best advantage and offers case histories to show how corrosive problems have been overcome in many fields. A copy of this helpful guide, "Where to Use Coal Tar Protection" is available to you. Tapecoat Co.

(14) Proportional Mixers

A new catalog is available which will be of interest to users of gas fired industrial furnaces, ovens, etc. It describes the simultaneous controlling and accurate proportioning of air and gas with a single control valve for manual or automatic operation. A consistent air-gas ratio is maintained over the entire range of the mixer capacity. The self-locking feature of the mixer control adjustment eliminates changing of mixture caused by hand locking adjustments. Mixer capacity tables are given for 5 different kinds of gases and for 8 air pressure ratings. (805A) Hauck Manufacturing Co.

(15) Pillow Blocks

A new bulletin is available which describes the new all-steel Dodge-Timken pillow blocks. Studied use has been made of colorful illustrations to help bring out the features of this new pillow block. This is particularly true of cut-away view which is shown in full color. Several pages are devoted to technical information which should prove helpful to any engineer in determining whether this new all-steel pillow block will solve a problem for him. The data contained in the bulletin will enable him to select the right size for any particular application. The data covers all-steel pillow blocks in sizes ranging from 2 15/16 in. through 10 in. (A-260) Dodge Manufacturing Corp.

(16) High Temperature Oil

Literature is available describing a new lubricant for use at temperatures of 500 F and over — Hi-Temp Oil 303 — which is light enough to be fogged easily in automatic lubricators yet provides high load carrying protection. This recently developed "hot-spot" lubricant combines molybdenum disulphide with a synthetic base and a pure, low-carbon-content petroleum oil. These properties impart exceptional lubricity, high resistance to heat breakdown and reduce carbon build-up to a minimum on bearings exposed to elevated temperatures. Another outstanding feature, according to the literature, of this oil is its high stability. This lubricant will not separate in storage, making it particularly well-suited for automatic spray or mist dispensing equipment. E. F. Houghton & Co.

(17) Spacer Type Gear Coupling

Literature is available describing a new "spacer type" gear coupling which can be disconnected in a matter of seconds without wrenches or special tools. The new coupling, similar in function and general design to conventional flange-and-bolt spacer types, makes it possible to remove the hubs from either shaft without disturbing the mountings of the connected units. The Sier-Bath spacer type, however, due to its simplified method of closure, can be assembled and disassembled in a fraction of the time necessary with other types. The new coupling consists of flexible hubs on both the driver and driven shafts. The center unit, or "spacer," has specially designed teeth at either end, cut in such a manner that they mate with each sleeve in a spline fit. These connections have no angular or off-set flexibility, but allow for end-float. The two sleeves connect the driver and driven units through the spacer. This gear coupling is available in stock size from 7/8 to 3, hp 4 to 80, per 100 rpm. Spacer lengths range from 4 3/8 in. to 37/8 in. Larger sizes and other spacer lengths are available on request. Sier-Bath Gear & Pump Co., Inc.

(18) Fuse Catalog

A new, complete fuse catalog has just been issued by General Electric's Construction Materials Division. Covering renewable time-delay fuses, one-time fuses, plug fuses, fuse holders, and copper link fuses, the catalog makes use of numerous illustrations and drawings. A technical data section is also incorporated in the catalog and covers such subjects as how a fuse operates, maintenance hints, excerpts from the 1951 National Electrical Code pertaining to fuses, and dimensions of fuses and fuse holders. (16-132) Construction Materials Division, General Electric Co.

(19) Steel Castings

"Quality Steel Castings Through Controlled Foundry Practices" is the title of a new bulletin available to you. The bulletin tells about carbon and alloy steel castings and how they are made in Ohio Steel Foundry's plants. A second bulletin is also available describing "Fahrite" heat saver dry dampers. This bulletin tells why you can install these dampers and forget them. (S-552 and FD-49) Ohio Steel Foundry Co.

(20) Heavy-Duty Industrial Trucks

Heavy-duty ram and fork trucks, with capacities from 12,000 to 60,000 lb are the subject of a colorful new brochure, just released. The free literature contains nearly a dozen action photos showing these handling giants in action transporting coils and sheet steel. Various applications within a plant are included. In addition, 11 models are described; all are detailed according to load capacity, overall dimensions. One section is devoted to the trucks' engineering features. Included among those listed are the caster trail axle, for easy nonreversible turning; contactor control, for low maintenance and heavy current-carrying capacity; hydraulic steer, for accurate, effortless steering; center-sill type frame, for extra load carrying capacity and to withstand abuse; hydraulic brakes, for quick, sure stops; alloy steel uprights, for long, trouble-free life; packaged power plant, for reserve of power and for ease of maintenance; Elwell-Parker built motors, for extra power when it is needed; and roller mounted elevator, for smooth lifting and low maintenance. Elwell-Parker Electric Co.

(21) Regulating Valves

Double-seated rotary stem regulating valves for on-off or narrow band proportional control are fully described and illustrated in a new four-page specification sheet. These valves are available for lever-and-weight actuation with either plain or outboard bearing construction. The new sheet gives pertinent data such as size, construction, body-temperature ratings and complete mounting dimensions. Also included are complete details on ordering data. (423) Industrial Division, Minneapolis-Honeywell Regulator Co.

(22) Plant Layout

The third in a series of valuable booklets designed for administrating and operating executives of industry, "Plant Layout" is now available. This booklet which was preceded by ones detailing the subjects, "Material Handling" and "Industrial Maintenance," cover such important phases as the work area, how to develop a better layout, layout planning, work area planning, and basic principles of good layout. Other topics detailed: balanced motions, a fixed place, using gravity and drop delivery, using holding devices, pre-positioning of tools and materials, making parts in multiples, and using ejectors and clamps. Two pages of the booklet are devoted to an improvement check sheet which poses more than two dozen questions which are designed to aid in evaluating a company's existing layout. Wheeler Associates, Inc.

(23) Worksaver Tractor

A new 4-page booklet describing the model "MT Yale Worksaver" heavy-duty electric tractor for industrial towing applications is available. The booklet describes the features of the tractor, and presents a complete set of specifications. (P-996). Yale & Towne Manufacturing Co., Philadelphia Division.

(24) Babbitting Practice

A new booklet published by Federated Metals Division, American Smelting and Refining Co. outlines basic steps for the prevention of common bearing failures. "Hints On Babbitting Practice" covers everything from the choice of metal for a particular bearing application through the correct pouring practice to in-service maintenance. Much of the machinery in American industry relies on babbitted bearings for efficient operation. Bearing failures cause machinery damage and lead to losses in downtime. Proper lubrication, a strict maintenance schedule, and operation of the bearing at the speed and load for which it was designed are advised for longer bearing life and reduced maintenance costs. This and other information on babbitted bearings is contained in the booklet. (146). Federated Metals Division, American Smelting and Refining Co.

(25) Open Channel Meter

Just published is a bulletin describing a recently-announced line of the open channel flow meters. The bulletin describes the application of the instruments to the measurement of the flow of water, sewage, industrial plant effluent, irrigation water and other liquids through weirs and flumes of all types. (F1606). Bristol Co.

Postage Will be Paid by Addressee

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY CARD
First Class Permit No. 1963, Sec. 34.9, P. L. & R. Pittsburgh, Pa.

IRON & STEEL ENGINEER
1011 EMPIRE BUILDING
PITTSBURGH 22, PA.

IRON & STEEL ENGINEER

Send The *free* Booklets Circled Below:

FEBRUARY, 1953

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
19	20	21	22	23	24	25	50	51	52	53	54	55	56	57	58		
59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74		
75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90		
91	92	93	94														

NAME _____ TITLE _____

DEPARTMENT _____

COMPANY _____

CO. ADDRESS _____

CITY _____ ZONE _____ STATE _____

PUBLICATIONS CURRENTLY OFFERED by Iron and Steel Engineer Advertisers

ITEM	COMPANY	BULLETIN	DESCRIPTION
50	ADAMS CO., INC., R. P.	BULLETIN 691	Adams Poro-Stone filters.
51	AIR PRODUCTS, INC.		Air Products generators.
52	AJAX FLEXIBLE COUPLING CO., INC.		Ajax flexible couplings.
53	ALDRICH PUMP CO.	DATA SHEET 61-2	Aldrich descaling nozzles.
54	AMERICAN AIR FILTER CO., INC.	BULLETIN 241	Multi-duty automatic air filters.
55	AMERICAN BRAKEBLOK DIVISION, AMERICAN BRAKE SHOE CO.		A-B-K bearings.
56	AMERICAN CHEMICAL PAINT CO.		"Rodine."
57	BLISS CO., E. W.	BULLETIN 44	Bliss slitters.
58	BROOKS OIL CO.		Leadolene Klingfast.
59	BROWNING AND CO., INC., VICTOR R.	BULLETIN "E"	Browning mill type cranes.
60	CLEVELAND WORM AND GEAR CO.	CATALOG 400	Cleveland worm gears.
61	CRANE CO.	CATALOG 53	Crane valves.
62	CUNNINGHAM CO., M. E.	CATALOG 100	"Safety" tag embossing and tagging outfit.
63	CURRY AND CO., INC., ALBERT		Steel plant equipment.
64	DE LAVAL SEPARATOR CO.	BULLETIN 500	DeLaval mill lubrication systems.
65	DOWELL, INC.		Steel mill maintenance cleaning.
66	ELECTRIC CONTROLLER & MFG. CO.	BULLETIN 900	SW all-welded magnets.
67	ELECTRIC CONTROLLER & MFG. CO.	BULLETIN 942	EC&M welded plate resistors.
68	ELECTRIC SERVICE MANUFACTURING CO.		Keystone integrated aluminum conductor system.
69	ELLIOTT CO., CROCKER-WHEELER DIVISION		Mill motors.
70	FARREL-BIRMINGHAM CO., INC.		Roll grinders.
71	FOOTE BROS. GEAR AND MACHINE CORP.	BULLETIN LPB	Line-O-Power drive.
72	FOXBORO CO.	BULLETIN 407 AND ENGINEERING DATA SHEET 330-1	Moisture control for furnace air blast.
73	GENERAL ELECTRIC CO.	BULLETIN GEA-4654	Describes G-E d-c mill motors.
74	GULF OIL CORP.		Gulf E.P. lubricants for rolling mill gears and pinions.
75	HARNISCHFEGER CORP.	BULLETIN C-42	P&H mill type cranes.
76	INDUSTRIAL GEAR MFG. CO.		"A Pictorial Trip Through Industrial."
77	JOHNS-MANVILLE	BROCHURE IN-134A	Superex block insulation.
78	JOHNS-MANVILLE	BROCHURE PK-46A	Precision-molded clipper seals.
79	KOPPERS CO., INC.		Catalog giving details, descriptions, engineering drawings, capacity tables and photographs.
80	LEEDS AND NORTHRUP CO.	CATALOG ND46	Speedomax instruments.
81	LOVEJOY FLEXIBLE COUPLING CO.		Lovejoy flexible couplings.
82	LUBRIPLATE DIVISION, FISKE BROTHERS REFINING CO.		"Lubriplate Data Book."
83	MINNEAPOLIS-HONEYWELL REGULATOR CO., INDUSTRIAL DIVISION	BULLETINS 1501 AND 1502	ElectroniK program controllers.
84	MOHR & SONS, JOHN		Mohr hot blast stoves.
85	POOLE FOUNDRY AND MACHINE CO.		Flexible couplings.
86	POST-GLOVER ELECTRIC CO.	BULLETIN 500	P-G limit switch resistors.
87	PYLE-NATIONAL CO.	BULLETIN 5015	Gyralites.
88	RELIANCE ELECTRIC AND ENGINEERING CO.	BULLETIN C-2201	Reliance dual-cooled motors.
89	SPRAYING SYSTEMS CO.	DATA SHEET 3997	Descaling nozzles.
90	TAYLOR SONS CO., CHAS.	BULLETIN 315 BULLETIN 313	Tasil ramming mixes. Tasil hydrocast.
91	UNITED STATES GRAPHITE CO.		Standard USG brushes.
92	WAGNER ELECTRIC CORP.	BULLETIN MU-185	Wagner protected type motors.
93	WESTINGHOUSE ELECTRIC CORP.	BOOKLET B-4730	Mill motor control.
94	WESTINGHOUSE ELECTRIC CORP.	BOOKLET B-4695	Westinghouse equipment for arc furnaces.

Postage Will be Paid by Addressee

No Postage Stamp Necessary If Mailed in the United States

IRON & STEEL ENGINEER

Send The *free* Booklets Circled Below:

FEBRUARY, 1953

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
19	20	21	22	23	24	25	50	51	52	53	54	55	56	57	58		
59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74		
75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90		
91	92	93	94														

NAME _____ TITLE _____

DEPARTMENT _____

COMPANY _____

CO. ADDRESS _____

CITY _____ ZONE _____ STATE _____

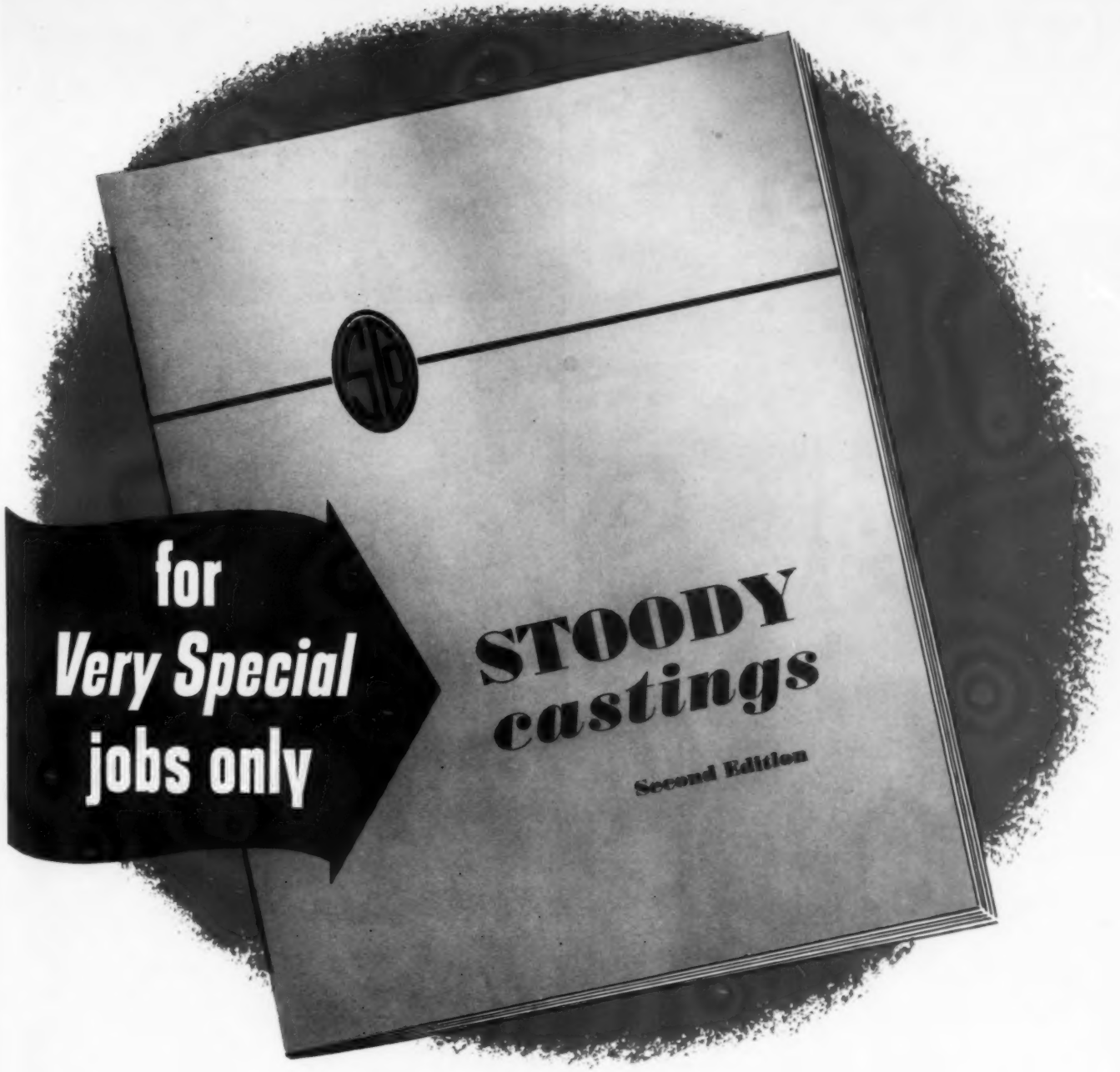
BUSINESS REPLY CARD

First Class Permit No. 1963, Sec. 34.9, P. L. & R. Pittsburgh, Pa.

IRON & STEEL ENGINEER

1011 EMPIRE BUILDING

PITTSBURGH 22, PA.



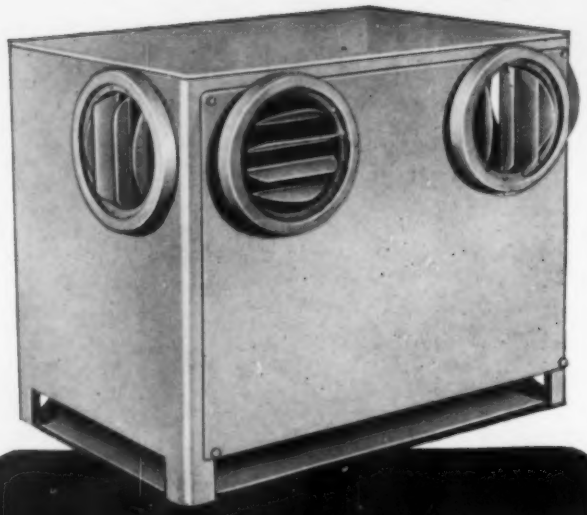
Once in a while you'll come across unusual operating conditions where ordinary castings just "can't take it." Perhaps the abrasion factor is too severe, the heat is too high or the element of corrosion enters the picture. Cost is of little importance *if you can get a casting that will work without frequent shut-downs for replacement!*

Stoody produces extraordinary centrifugal castings of non-ferrous alloys, characterized by a very dense grain structure, high wear resistance and compressive strength. Dimensions are limited by the casting method used and only such shapes as may be produced from cylindrical forms are available—sleeves, bushings, guide rolls, straightening rolls, forming rolls and the like. They are supplied finish-machined, never as cast.

Although first cost of Stoody castings appears high, *service life makes that cost negligible!* Stoody Company would be glad to supply specific recommendations on the basis of information you furnish us. Please outline your use of castings in order that we may more accurately answer your requirements.

STOODY COMPANY

11942 EAST SLAUSON AVENUE, WHITTIER, CALIF.



New Features Less Space

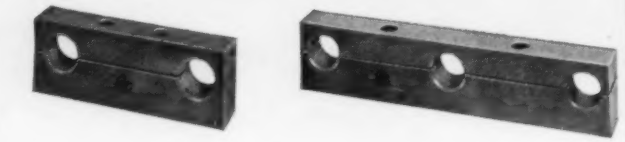
The new Lintern Crane Cab Heater, Model 53 VHG—a general purpose heater — is 15″ shorter than any previous Lintern model.

Yet it delivers 360 c.f.m., the same circulating capacity as larger units. And two other features make it ideal when heat is needed.

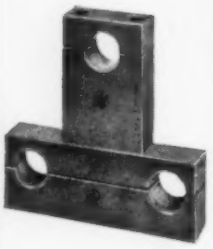
A new plastic tray type electrostatic filter is used in conjunction with a tray type activated carbon filter. The only maintenance required is that the plastic filter be given a cold water bath when it gets dusty. No re-oiling needed either!

WRITE TODAY FOR COMPLETE DETAILS

THE LINTERN CORPORATION
P. O. Box 428 • PAINESVILLE, OHIO



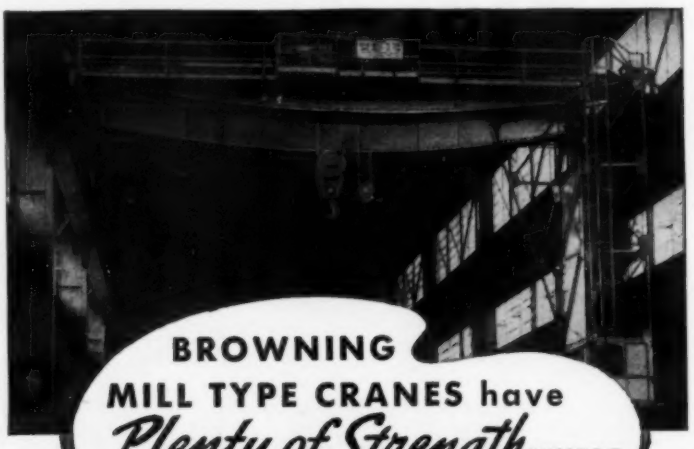
RUGGED!



Adalet Cable Racks are sturdy "Sali" **canvas base** phenolic material . . . defy breakage. Reduce maintenance with these **extra** strong racks. All sizes, all types.

Literature on request.

THE ADALET MANUFACTURING CO.
14300 LORAIN AVE.
CLEVELAND 11, OHIO



BROWNING MILL TYPE CRANES have *Plenty of Strength* WHERE STRENGTH IS NEEDED!

Browning Mill Type Cranes are built in accordance with A. I. S. E. specifications. They incorporate the types of motors and controls on which your mill or industry has standardized. This flexibility adapts your VRB crane *perfectly* to your needs. Only the finest materials are employed. Browning heavy duty cranes meet the most rigid demands and satisfy the most critical users. Our design, placing plenty of strength wherever needed, is the outgrowth of 48 years' experience in the crane industry.

Write for our Bulletin "E".

"Built as you yourself would build them"

VICTOR R. BROWNING & COMPANY, Inc.
BOX 309, WILLOUGHBY (CLEVELAND), OHIO
Designers and Builders of Electric Overhead Traveling Cranes and Hoists and Electric Revolving Cranes

CLEAN WATER IN YOUR PLANT

Prolongs the working life span of all equipment that is cooled, heated or actuated by water.

Adams Poro-Stone filters convert your turbid supply to water of any degree of clarity you require. Used with or without filter aid, operated manually or automatically, Poro-Stone filters may be spotted throughout the plant at points of need or centrally installed for plantwide distribution.

Complete, packaged Adams filtration plants include filter aid precoat tank, continuous filter aid feeder, pressure backwash system, pump, valves and piping.

WRITE FOR BULLETIN 691

R. P. ADAMS CO., INC.

223 E. PARK DRIVE, BUFFALO 17, N. Y.

NAIL IDENTIFICATION TAGS TO STEEL!

—with the

"SAFETY" TAG EMBOSSING and TAGGING OUTFIT

It's hard to believe, but it's true—this Outfit enables you to quickly nail metal identification tags to hot or cold steel ingots, billets, slabs, etc. Tags are embossed, pierced and nailed to steel by swinging hammer in the ordinary manner. Send for complete data today on this remarkable unit.

Write for Catalog 100.

M.E. CUNNINGHAM CO.
SAFETY STEEL STAMPS

1041 Chateau Street • Pittsburgh 33, Pa.

Heroult
ELECTRIC MELTING FURNACE

. . . as ever, the dependable furnace for the production of high-grade stainless, alloy and rimming steels.

Removable roof of new design now available for the larger furnaces.

AMERICAN BRIDGE DIVISION
UNITED STATES STEEL CORPORATION
General Offices: 525 William Penn Place, Pittsburgh, Pa.

Contracting Offices in New York, Philadelphia, Chicago, San Francisco and other principal cities

USS **AMERICAN BRIDGE**
UNITED STATES STEEL

● **Compare features carefully when you specify D-C Contactors. All have exclusive points, but be sure that they accrue to your advantage. There is a reason behind each feature of E. E. Contactor construction... a reason that saves maintenance, gives extra years of service, lowers operating costs or improves performance. Thirty years of experience building the finest motor-control apparatus is your guarantee that E. E. Contactors are built with *your* requirements in mind.**

ONLY EUCLID CONTACTORS HAVE ALL TEN

1. Stamped-steel, welded construction that assures extra strength.
2. Light-weight, fast-moving parts that provide quick operation. No die-cast parts.
3. Self-lubricating, porous-bronze bearings.
4. Compact design... lessens required mounting space.
5. Lift-off arc shields for quick contact inspection.
6. Standard electrical interlock has normally open and normally closed contacts, electrically separate.
7. Stainless-steel springs on both auxiliary and main contacts.
8. Extra wide, heavy-duty contacts (¾").
9. Arc-centering feature... assures longer arc-shield life.
10. Unusually high rupturing capacity... highly efficient blow-out system.

Ask your E.E. Representative for more information, or write:

The Euclid Electric & Mfg. Co.
MADISON, OHIO

For Rigidity of Design and Construction

Custom Engineered

FURNACES BY GW

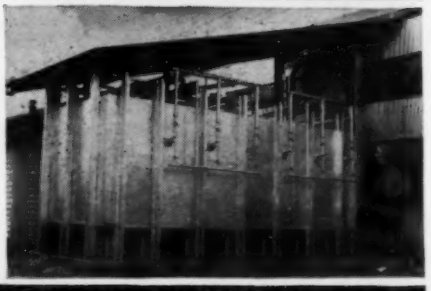
Grant Watson

Every furnace installed by Grant Watson is individually engineered to meet your requirements and specifications. Grant Watson does the *whole* job for you...design and installation from the ground up, plus regular cost-free service after installation. This complete package eliminates all sub-contracts to save you money. Grant Watson heating and heat treating furnaces are both gas and oil fired, for reheating slabs, billets, rods, bars and blooms; forging; soaking pits; annealing and normalizing; stress relief; and other industrial heating applications.

Grant Watson Custom Engineered Car Bottom Furnaces Are Built to "Stay Put"

Exterior view of steel shell during construction.

Interior view after lining. Furnace operates to temperatures of 1800 F.



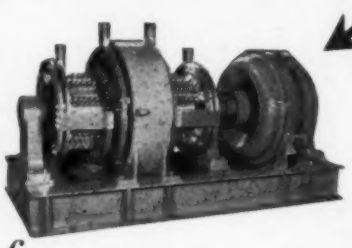
Exterior view of complete furnace. Drive unit, mounted in car, operates by remote control from panel.

Write, wire or call for instant service on custom engineered furnaces to meet your requirements and specifications.

GRANT WATSON CONSTRUCTION CO. 1398 So. Santa Fe Drive Denver, Colorado

COLUMBIA

MOTOR GENERATORS



for • Electroplating
• Anodizing
• Electrocleaning
• Electropolishing

TONG TEST
A.C.—D.C.
AMMETERS

• TANK RHEOSTATS
• REVERSING SWITCHES

Write for Descriptive Bulletins

COLUMBIA ELECTRIC MFG. CO.
4543 HAMILTON AVE. CLEVELAND 14, OHIO

I Wish . . .

to enter one year's subscription for the IRON AND STEEL ENGINEER at $7.50 per year:

☐ Check enclosed

☐ Bill me later

I desire information on membership in the Association of Iron and Steel Engineers:

☐ Application blank

☐ Data

Name_____

Title_____

Company_____

Mailing Address_____

Mail this coupon to:

Association of Iron and Steel Engineers
1010 Empire Building
Pittsburgh 22, Penna.

LESS DOWN TIME...

when you CHANGE over to SPRAYING SYSTEMS descaling NOZZLES

If you want to materially reduce down time on rolling mills due to clogged nozzles, try Spraying Systems descaling nozzles. Large orifice diameter permits passage of practically all particles that ordinarily clog other types of nozzles. Spraying Systems nozzles produce an effective uniform flat spray, free of streaks, with an impinging force equal to over 96% of the maximum potential. Typical user is the Homestead District Works of U. S. Steel illustrated above. Nozzles are made of hardened stainless steel in a wide range of capacities and spray angles. Your inquiry is invited . . . write for Data Sheet 3997.

SPRAYING SYSTEMS CO.
3262 RANDOLPH STREET • BELLWOOD, ILLINOIS

Also write for Data Sheet 4516 . . . Pneumatic Atomizing Nozzles for direct spray gear lubrication.

ANOTHER FALCON CONTRIBUTION

TO OPERATING EFFICIENCY

If air could conduct heat better than water, you would circulate air through your copper cooling plates. But you are aware of what trapped air does to a tuyere or to a bosh plate. It has been a major threat to operating efficiency . . . and Falcon non-ferrous casting specialists have come up with the answer. Falcon has created an AIR-FREE COOLING PLATE and an AIR-FREE TUYERE.

It is another of the many examples of Falcon pioneering . . . constantly affording you the current best in copper castings, through specialization . . . and contributing immeasurably to longer equipment life and maximum reduction of down-time.

• • • • • • • • • • •

For Blast Furnace Copper Castings delivered when you want them . . . and in the best quality

Licensed Manufacturers of All Patented Designs

DEPENDABLE FOR 62 YEARS · SINCE 1890

Telephone Collect 3-4186

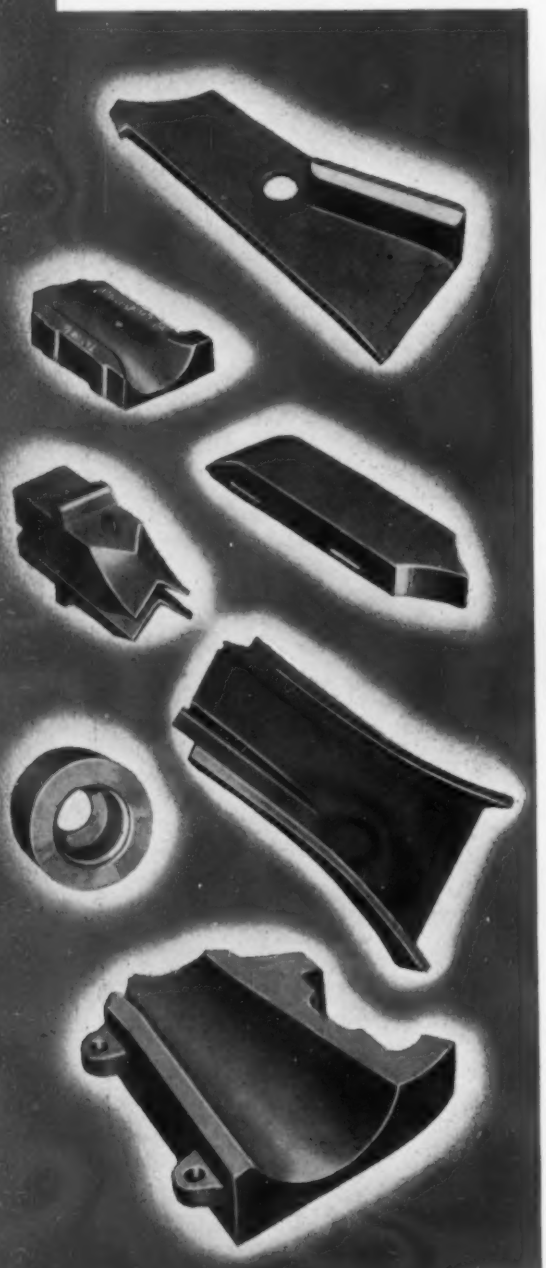
FALCON BRONZE CO.

YOUNGSTOWN 3, OHIO

Established 1890 · Incorporated 1895

trantinyl

guides the steel industry



ROLLING MILLS:
bar, hoop, strip, shape
mill guides; and rollers

SEAMLESS TUBE MILLS:
guide shoes, rolling
mill plugs and rolls,
piercer points, etc.

ELECTRIC WELD TUBE MILL:
forming rolls, planishing
rolls, tool holders, etc.

STRAIGHTENING MACHINE GUIDES

HEAT RESISTING CASTINGS

YOUNGSTOWN ALLOY CASTING CORP. • YOUNGSTOWN, OHIO

Equipment News...

TACONITE PILOT PLANT

▲ An interim report on the pilot plant work for heat hardening of pellets from magnetic taconite concentrates now being carried out at Allis-Chalmers Manufacturing Co. in cooperation with the Arthur G. McKee Co., was presented recently by G. V. Woody, manager of Allis-Chalmers processing machinery department,

The interim report stated that the pilot plant as originally announced was completed and two test runs, one for two hours and one for seven hours, were made. Taconite concentrates used came from the babbitt pilot plant.

During the seven hour run, a three hour test was conducted and data was obtained as follows:

The feed from the table feeder to the pellet forming drum was 3,120 lb per hr at 5 per cent moisture. Pellets smaller than ⅜ in. and larger than ¾ in. were screened out before leaving the drum.

The pellets were then sent through a drying drum where some of the moisture picked up in the pelletizing operation was removed.

The "burning" or heat hardening of the pellets is a continuous one involving a traveling grate. The theoretical output of the pilot plant grate when traveling at 2 inches per minute was computed to be 1.22 short tons per hour and the actual output was 1.15 short tons per hour. This capacity is probably less than half the capacity which will be attained when the grate is run at full speed. Bulk weight of the pellets entering on the grate equalled 135 lb. per cubic ft while that of the pellets discharged from the grate equalled 116 lb per cu ft.

The total heat consumed in the process was approximately 650,000 Btu per short ton.

The final product was subjected to a tumbling test in a standard coke testing drum. Fifty pounds were put into a tumbling mill and revolved for approximately four minutes at a speed of 24 revolutions per minute. The subsequent screen analysis yielded 12 per cent minus 10 mesh fines.

Research and test work has barely been started and the whole story will not be known for several months. It was pointed out that the maximum grate output must still be determined. Work is also being carried out to improve predrying of the pellets on the grate, a factor which when achieved, it is hoped, will further increase the output.

Mr. Woody summarized by saying that when facilities for continuously introducing concentrate into and continuously taking pellets away from the pilot plant are completed, it will be able to operate under all weather conditions. Production of pellets per sq ft of grate area can be increased to a point where the capacity of a commercial unit of from 1500 to 2000 tons per day can be expected. Also, Btu consumption per ton of pellets should be considerably less when experimental work is complete and a commercial plant installed.

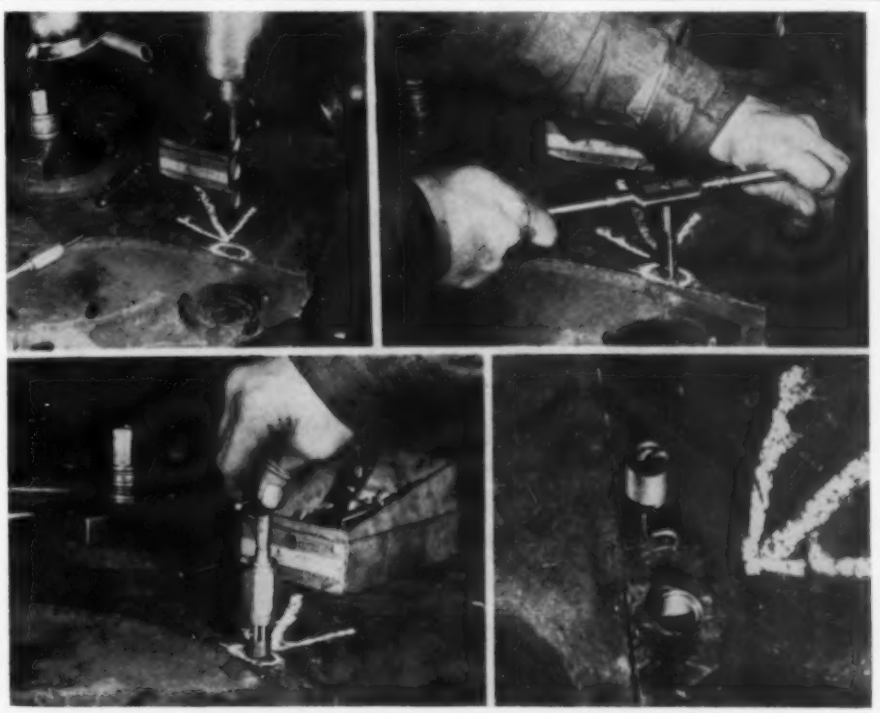
Preliminary work on hematite (non-magnetic taconite) concentrates indicates that heat hardening to a point comparable with magnetic concentrates is possible but not with the pilot plant as now designed.

WIRE THREAD INSERT

▲ Stainless steel helical-wire thread inserts are reducing equipment downtime wherever machine operations are impaired by stripped or worn threaded holes.

Time and cost savings up to 80 per cent have been reported when comparing the wire insert method of thread repair with previous methods. In addition, Heli-Coil thread inserts provide higher loading strengths in all materials and are more resistant to wear, vibration, seizing, galling and corrosion than original threads.

Tapped threads in all types of industrial castings and machine housings—induction furnaces, diesel engine cylinder blocks, automotive fuel pumps, air conditioning fan bases, jet engines, electric motor cases, pump housing castings, printing presses, railway motor bases, punch press bolster plates, aircraft fire extinguishers and business machine housings,



After the worn thread is cleaned out, top left, and re-tapped, top right, a Heli-Coil wire thread insert is quickly installed in the hole, bottom left, with an inserting tool. The reconditioned hole is shown at bottom right with an unmounted insert and the removed inserting tag (used for driving) on the casting surface.

to mention a few—may be quickly and economically restored with these inserts.

Heli-Coil thread inserts are available in the following standard thread classifications: 4-40 to 1½-6 sizes in the national and unified coarse thread series; 6-40 to 1½-12 in the national and unified fine thread series; 10-1.0mm to ⅞-18 in the automotive spark plug series; 14-1.25mm to 18-1.5mm in the aviation spark plug series; and ⅛-27 to 1-11½ in the national pipe thread series. These inserts are supplied in 1, 1½, 2, 2½ and 3-diameter lengths. For special applications, non-standard threads and sizes can also be supplied.

In comparison with conventional thread repair operations—the oversize thread method, the build-up by welding method, and the solid bushing method—the wire insert operation requires only: drilling out the damaged thread, re-tapping the hole slightly oversize with a Heli-Coil tap and winding the wire insert in the newly tapped hole. This produces a permanent thread of the original size.

Because they are slightly larger than the hole into which they are installed, these thread inserts are self locking. No amount of vibration or bolt tightening will loosen them. However, they can be quickly and easily removed with an extracting tool if this should become necessary.

Heli-Coil thread inserts are manufactured by Heli-Coil Corp.

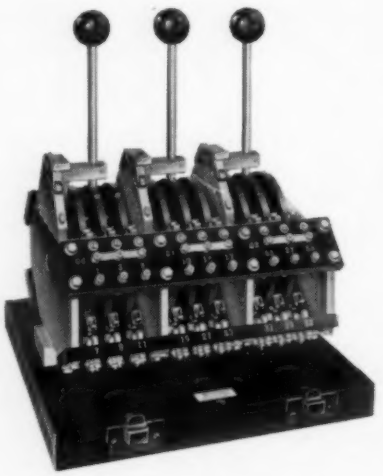
MASTER SWITCH

▲ Type MD master switches, manufactured by Post-Glover Electric Co., are designed for general application, mill service. Their use is particularly advantageous where two or more master switches are required at any one location, where longitudinal mounting space for switches is limited and where for convenience of mounting and maintenance, it is desirable to have two, three, or four single switches under one cover.

Sturdy construction is used throughout these master switches. The following description is illustrative of the features: *Star Wheel and Ratchet* — Accurately machined notches indicate to the operator each operating point with a pronounced position at center. The star wheel is steel heat-treated to give extreme hardness and toughness, thereby minimizing wear of the notches. A hardened steel roller operates over the notches to give the ratchet effect.

Bearings—The cam assembly revolves 6¼° per point in either direction on a stationary hardened stainless steel shaft. The hub of the movable assembly is equipped with a self-lubricating oil-impregnated porous bronze bearing.

Cams — Contact actuating cams are made of accurately machined laminated phenolite of high tensile, flexural and compressive strength. Cams are rigidly bolted to the hub assembly.



Contact Assemblies — Double break contacts are provided. The fine silver contact surfaces assure excellent electrical connection. Cleaning of contacts is not necessary. Rollers are made of hardened steel and plated to prevent corrosion. Both roller and movable arm rotate on self-lubricating bearings. Contacts are readily renewable.

Terminal Strips — Laminated phenolite having high compressive, tensile, and flexural strength, excellent dialectric characteristics, and extremely low water absorption is used for this purpose.

HIGH-FREQUENCY HEATING

▲ The year passed witnessed an interesting example of using high-frequencies to heat metal for forgings, which is a comparatively new use of radio-frequency energy for heating. In this particular application it is desired to bring an irregularly shaped billet up to 2100 F for forging into gas-turbine blades. These billets are about a foot long, weigh about a pound, and are roughly cylindrical but with two ball-like bumps near the center of the bar.

The high-frequency power for this task is supplied by four 150-kw, 9600-cycle motor-generator sets, which feed a total of ten work-handling machines. A walking-beam and escapement arrangement feed the billets through the work coil at the rate of one every 15 seconds. Special precautions are taken to prevent the billet from contacting the work coil enroute which would cause a short-circuit that would overload the unit or damage the part being heated. It was also necessary to design a unit that heats the billets without heating the carriage mechanism. A novel shape of carrier was developed in which two sets of currents are induced — but in opposite phase, and hence nullify each other. The carriers are also made of very thin metal to reduce the amount of heat induced in them at these comparatively low frequencies.

LOCOMOTIVE EQUIPMENT

▲ General Electric Co. supplied electrical equipments for more than 1000 diesel-electric locomotives during 1952, according to G. W. Wilson, manager of the company's locomotive and car equipment department at Erie, Pa.

These electrical equipments, comprising motors, generators and control, were made for both railroad and industrial-type locomotives.

Despite production losses resulting from the steel and American Locomotive Co. strikes and further government cutbacks in materials, Mr. Wilson pointed out that this year "has been a good year in the locomotive business."

Although down about 10 per cent over 1951, he said that production is well over what is considered an average year.

Highlighting the department's activities for the year, Mr. Wilson pointed to the sale of 15 additional gas turbine electric locomotives to the Union Pacific Railroad. The Union Pacific has six gas turbines in operation of a previous order of 10. These six were delivered during the first part of the year and the remaining four will be delivered in 1953. Delivery on the newest order for 15 will begin in 1954.

Exide-Ironclad
BATTERIES

ARE YOUR BEST POWER BUY— AT ANY PRICE

They ASSURE high maneuverability of trucks . . . rapid, accurate handling of material. PROVIDE uniform rate of material handling with no unscheduled down time. SHOW lowest costs of operation, maintenance, repair, depreciation . . . inherently safe. For all types, sizes, makes of battery-electric trucks—hand or rider. Call in an Exide representative, and let him prove these facts.

THE ELECTRIC STORAGE BATTERY COMPANY
Philadelphia 2
Exide Batteries of Canada, Limited, Toronto
"Exide-Ironclad" *Reg. Trade-mark U. S. Pat. Off.*

FOR YOUR VOICE OF ACTION

Femco

CRANEPHONES
provide low cost
COMMUNICATION
THROUGHOUT HEAVY INDUSTRY

Efficiency is improved—production goes up, when Femco equipment is installed. With Cranephones, you can talk from cab to floor, to office, and from cab to cab.

Other Femco Products of Merit include:

Femco AUDIOPHONES

Fixed-point industrial communication

Femco PORTAPHONES

Movable as your work progresses

- Femco Communication Systems GET THINGS DONE faster - better - cheaper!
- Easy to BUY or LEASE Easy to INSTALL and USE
- DEMONSTRATIONS ARRANGED

FARMERS ENGINEERING & MANUFACTURING COMPANY
IRWIN, PENNSYLVANIA

Ask for YOUR Femco Data Kit

Specialists in Electronic Communication and Control

The company will build 10 rectifier locomotives, an all-electric type of motive power which utilizes large rectifier tubes in converting alternating current to direct current, for the New York, New Haven and Hartford Railroad. This will be the largest application of rectifier locomotives in this country.

Eighty-three road switcher locomotives, to serve a wide variety of uses in both foreign and domestic applications, were ordered by the Army Transportation Corps. Delivery of these locomotives, which are being built by the American Locomotive Co., will begin in 1953.

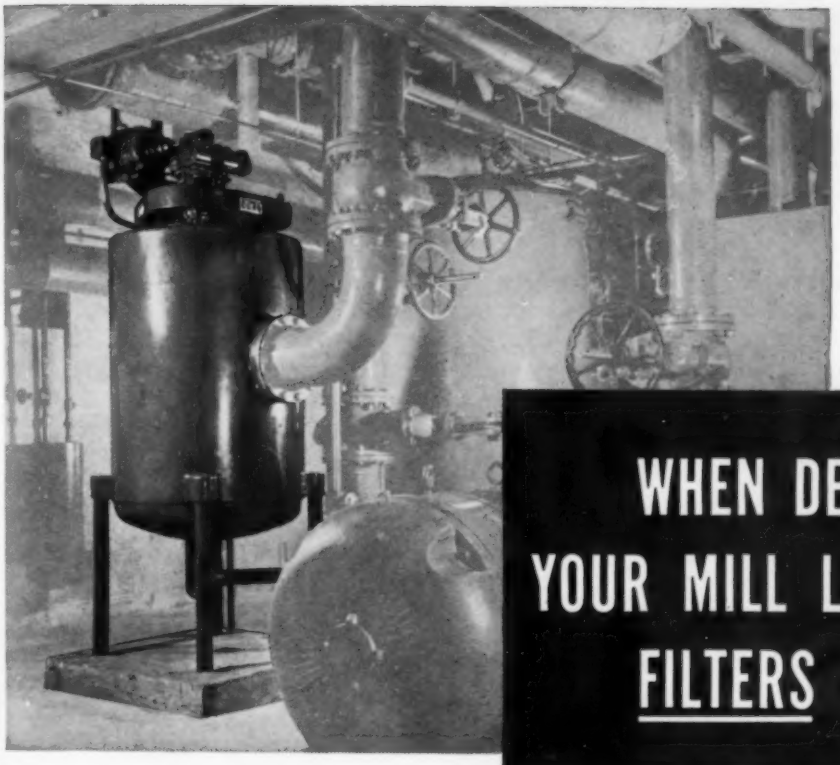
VALVE UNIT

▲ A small companion model to its well known line of cam operated valves has been announced by Ross Operating Valve Co. Excluding the cam roller, the new unit is less than 4 in. high and has a 3 in. by 3½ in. base. It is a ¼ in., four-way valve with a long lever. The lever travel is less than 1 in.

Known as Ross valve No. 636, the new model is a small, rugged version of the Ross cam operated valve line which has served in many varied installations. It is especially suitable for low volume applications requiring a mechanically operated valve.

INDUSTRIAL HEATER

▲ An improved line of industrial heaters, which deliver large volumes of heated air for heating large areas which cannot be heated by more conventional methods, is available from the Sturtevant Division of Westinghouse Electric Corp. The self-contained units, which range from 100,-



WHEN DE LAVAL DESIGNS YOUR MILL LUBRICATION SYSTEM FILTERS ARE IMPORTANT

De Laval engineers have used Cuno Auto-Klean Filters for many years in designing steel mill lubrication systems. Utilizing a small motor to rotate the cartridges continuously and fixed scraper blades to prevent the accumulation of scale and sludge on the outside of the cartridges, these filters operate at constant efficiency and constant pressure drop. The result is uniform flow to bearings and gear mesh points.

Removal of sludge is easily done through a blow-off valve mounted on the bottom of the filter sump.

There are no filter bags to change or to rot out, and no cartridges to change. Power requirements are very low . . . cleaning is as inexpensive as it is easy. This means saving both space and labor.

Filters are only ***one*** of the many details that comprise De Laval engineered mill lubrication systems. Large or small, ***every*** De Laval system includes the four fundamentals shown in the left panel.

Write for Bulletin 500.

ALL DE LAVAL ENGINEERED MILL LUBRICATION SYSTEMS HAVE THESE SPECIFIC FEATURES:

1. Proper Selection of Pipe Size
2. Correct Metering of the Lubricant
3. Efficient Temperature Control
4. Purification of Lubricating Oil

For Large Mills:
Custom-built lubrication system

For capacities up to 50 gpm:
The self-contained Unilube
Single . . . Simplex . . . Double . . . Dual

THE DE LAVAL SEPARATOR COMPANY
Poughkeepsie, New York 427 Randolph St., Chicago 6
DE LAVAL SALES & SERVICE, INC.
447 Fourth Ave., Pittsburgh 19
DE LAVAL PACIFIC COMPANY
61 Beale St., San Francisco 5

DE LAVAL ENGINEERED SYSTEMS

"THIS LUBRICANT EXTENDED BEARING LIFE 50%"

—says REPUBLIC AVIATION CORP.
Makers of the famous F-84E THUNDERJET

"Under actual tests, LUBRIPLATE extended bearing life fifty per cent or better as compared to other lubricants. It was also found that, during test, LUBRIPLATE increased efficiency of machines twenty per cent by reducing friction loss. Republic has been using LUBRIPLATE successfully for the past eight years."

For nearest LUBRIPLATE distributor, see Classified Telephone Directory. Send for free 56-page "LUBRIPLATE DATA BOOK"... a valuable treatise on lubrication. Write LUBRIPLATE DIVISION, Fiske Brothers Refining Co., Newark 5, N. J. or Toledo 5, Ohio.

REGARDLESS OF THE SIZE AND TYPE OF YOUR MACHINERY, LUBRIPLATE LUBRICANTS WILL IMPROVE ITS OPERATION AND REDUCE MAINTENANCE COSTS.

000 to 2,500,000-Btu per hour in heating capacity and from 2,000 to 25,000 cfm in air velocity, may be floor, wall or ceiling mounted. They may be mounted in either upright or inverted position when wall-mounted. The new line includes a heavy duty model designed especially for steel, rubber, and paper mills.

Accessories available include filter boxes for built-in mechanical air cleaning and air-mixing boxes for controlled mixing of fresh and recirculated air.

SELF-CLEANING STRAINER

▲ A new automatic self-cleaning strainer, featuring a greatly improved design, has been achieving remarkable results through regular use by several industrial plants. The new strainer is designed and produced by S. P. Kinney Engineers, Inc. Made in 2 in. to 36 in. pipe line sizes, the strainer removes fine suspended particles from raw or process water, and disposes of them in an automatic self-cleaning manner. Units are also constructed of special non-corrosive materials to strain sea water, ammoniacal liquor, gasoline, oil, and various other liquids.

The strainer consists essentially of a rotating drum into which straining elements are retained. The drum is mounted on a vertical shaft and housed in a cast iron body.

The water or other liquid to be strained, enters through an inlet at the bottom of the housing and rises on the outside of the revolving drum. The liquid passes through the drum, while the dirt and foreign matter are retained on the surface of the strainer elements. Free of foreign matter, the clean liquid flows down the center of the drum to the outlet, which is diametrically opposite the inlet.

A backwash orifice is provided so that when the foreign matter, carried on the surface of the strainer elements, passes this vertical opening, a reversal of flow takes place; thus flushing the foreign matter from the strainer elements, leaving them clean. This reversal of flow is caused by a pressure differential between the interior of the strainer and atmospheric pressure. The drum rotates at a speed of six rpm, cleaning each row of elements every ten seconds.

A closed-top drum eliminates a wear and leakage point between the drum and body. At the bottom of the body, where the drum makes contact, a synthetic rubber seal is installed. The excellent composition and structure of this seal permits the achievement of a 100 per cent separation efficiency between the dirty and clean liquid. All the dirty liquid must flow through the strainer media, eliminating any possibility of by-passing. Over 100 lb pressure was tested against this seal with no evidence of any leakage.

The design of the strainer has been greatly simplified in that the body and lower supporting structure are cast into one form. Consequently, the necessity of costly machining operations to attach these two parts is eliminated.

The initial cost of this new strainer is much lower in comparison to other strainers in use today. Also, its durability of construction reduces maintenance costs considerably.

BABBITTING HINTS

▲ Federated Metals Division, American Smelting and Refining Co. has submitted several hints on babbitting practice.

Suggestions for Preventing Bearing Failures—Select the proper bearing metal. The recommendation of the equipment supplier or a reputable manufacturer of bearing alloys should be sought and followed. Generally speaking, tin-base babbitts are best for high speeds and heavy-duty service . . . lead-base babbitts for medium or low speeds and loads.

In making bearings, make sure that the melting pot is clean, heat

We Serve Steel

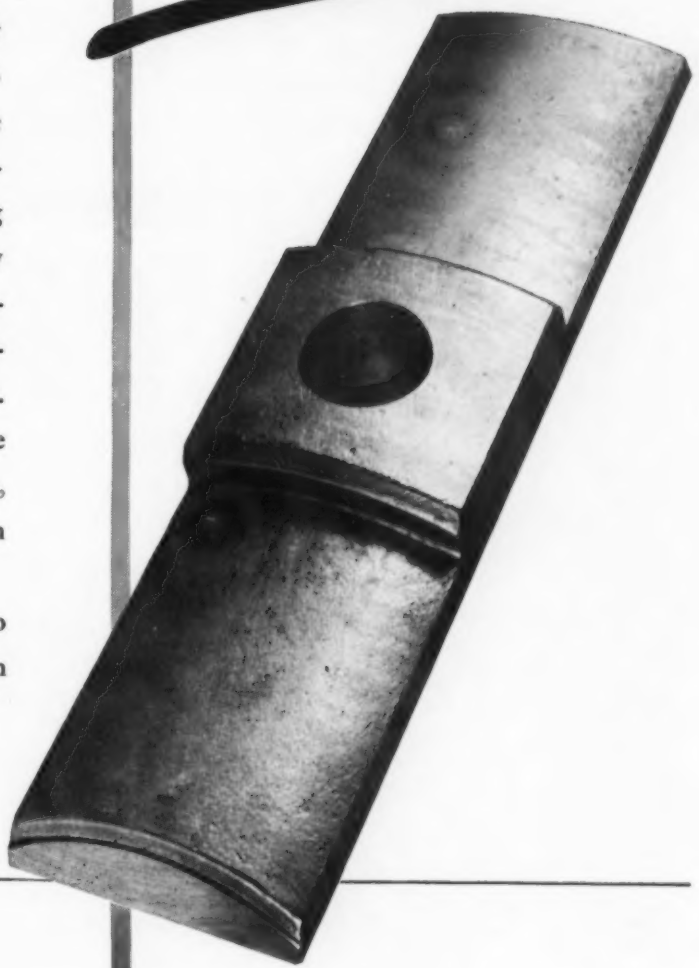
Knowing Copper Alloys

Better Best

We specialize in copper and copper-base alloys such as bronze. And we cast these metals for steel industry use by the most advanced methods. For example . . . this aluminum bronze slipper is made by our permanent mold technique and requires *no machining* after casting except for the pin hole. Oil grooves are actually cast-in. Surface hardness is completely controlled, and our customers realize dollar savings through our production-run economies.

National Bearing Division offers you the benefits of more than 50 years of experience, metallurgical research and production-run facility development.

Our 6 centrally located plants are ready to serve you. Contact National Bearing Division for full information.



A FEW NATIONAL BEARING STEEL INDUSTRY PRODUCTS: Bosh Plates • Monkeys • Tuyeres • Coolers • Mantel Plates • Stack Plates • Roll Neck Bearings • Housing Nuts • Babbitt Metals • Slippers

You're invited to visit us at our plant in Meadville, Pa. . . . We'll be glad to have you know us better.

AMERICAN Brake Shoe COMPANY

NATIONAL BEARING DIVISION

4936 Manchester Avenue • St. Louis 10, Mo.

PLANTS IN: ST. LOUIS, MO • MEADVILLE, PA. • NILES, OHIO • PORTSMOUTH, VA. • ST. PAUL, MINN. • CHICAGO, ILL.

REVOLUTIONARY NEW MAGNET CHAIN LASTS 5 TO 15 TIMES LONGER!

The new TM Frictionless Magnet Chain is now being manufactured by the S. G. Taylor Chain Company, Hammond, Indiana. Patented design keeps chain legs at 120° centers — prevents undue wear that otherwise results from friction, due to twisting. The entire assembly is manufactured from Taylor's Special Analysis Alloy Steel. This assures twice the strength — twice the safety factor of wrought iron assemblies. Controlled heat-treatment means uniformity throughout plus high resistance to shock, grain growth and work hardness at *all temperatures.* And TM Alloy Steel Chain's extreme hardness enables the assembly to withstand abrasion. These factors add up to lower Magnet Chain costs for you as they have for others in many industries. Write today for full details. S.G.Taylor Chain Co., Hammond, Ind.

MINIMUM WEAR
Special locating plate keeps legs at 120° centers—cuts friction, twisting and gouging.

RUGGED CONSTRUCTION
Ring and end link can not be separated. Entire assembly is made from TM Alloy Steel.

- ***Lasts 5 to 15 times longer.***
- ***Provides Increased Safety Factor.***
- ***Assures Twice the Strength.***
- ***Means Lower Costs for You.***
- ***Each chain is tested before shipment.***

TAYLOR MADE
A GREAT NAME IN
Chain SINCE 1873

S. G. Taylor Chain Co.
Dept. 5, Hammond, Indiana
Rush literature and prices on TM Alloy Steel Downtown Magnet Chain.

Name_____

Address_____

the kettle uniformly to prevent segregation, stir the molten metal thoroughly by using a long-handled steel rod with a perforated steel plate attached, control metal temperature with a pyrometer, do not allow the metal to cool while in the pot, or to stand overnight. Segregation will usually occur. Do not add drosses, sweepings, or skimmings. They usually contain detrimental impurities. The safest, and the least expensive procedure is to return all these materials to a reputable smelter for refining.

In bonding, machine the shell surface to a "phonograph" finish, avoid use of lubricant when taking the final cut, degrease in a commercial alkaline cleaner held just below its boiling-point, etch for three to five minutes in an aqueous solution of 50 per cent hydrochloric (muriatic) acid held at 160 F—180 F, if not clean, repeat degreasing and etching. Dip into flux held at a temperature of 150 F. A saturated solution of two parts of zinc chloride and one part of ammonium chloride in water is usually satisfactory. Dip the shell into a bath of molten bonding alloy (tinner's solder) kept about 150 F above its liquidus temperature. The shell should have a silvery appearance on removal from the bath. The shell should not be allowed to cool before casting the liner.

In casting, the shell should be at a temperature above the melting point of the bonding or tinning metal, the temperature of the mandrel should be approximately 100 F higher than that of the shell so that solidification can progress from the shell to the mandrel. The stream of metal should be poured against and moved around the circumference of the mandrel to prevent local overheating. Use a ladle of sufficient capacity to permit pouring the entire bearing at one time; this reduces the likelihood of cold shuts, laminations, or folds.

In the installation of bearings, make certain that all foreign particles, such as dirt, metal chips and lint, are wiped from the bearing and shaft with a lint-free material. Make certain that the clearances between the bearing and the shaft are adjusted in accordance with manufacturer's recommendations. Make certain that the shaft and the bearing are in proper alignment and that the tension of the bolts is even.

Here's why you save time and money
WITH FARREL® ROLL GRINDERS

These machines are extremely fast for either heavy roughing or producing as high a mirror finish as it is possible to obtain with wheels at present available. They grind straight, convex or concave rolls.

The crowning device produces a mathematically accurate curve, symmetrical on both halves of the roll, for either a convex or concave shape. It is easily and quickly set and requires no manipulation during operation. The same setting invariably produces exactly the same curvature and permits fixed, uniform and easily controlled accuracy of contour in all rolls.

Farrel roll grinders are available in two types and nine standard sizes. Write for descriptive bulletins.

FARREL-BIRMINGHAM COMPANY, INC., ANSONIA, CONN.

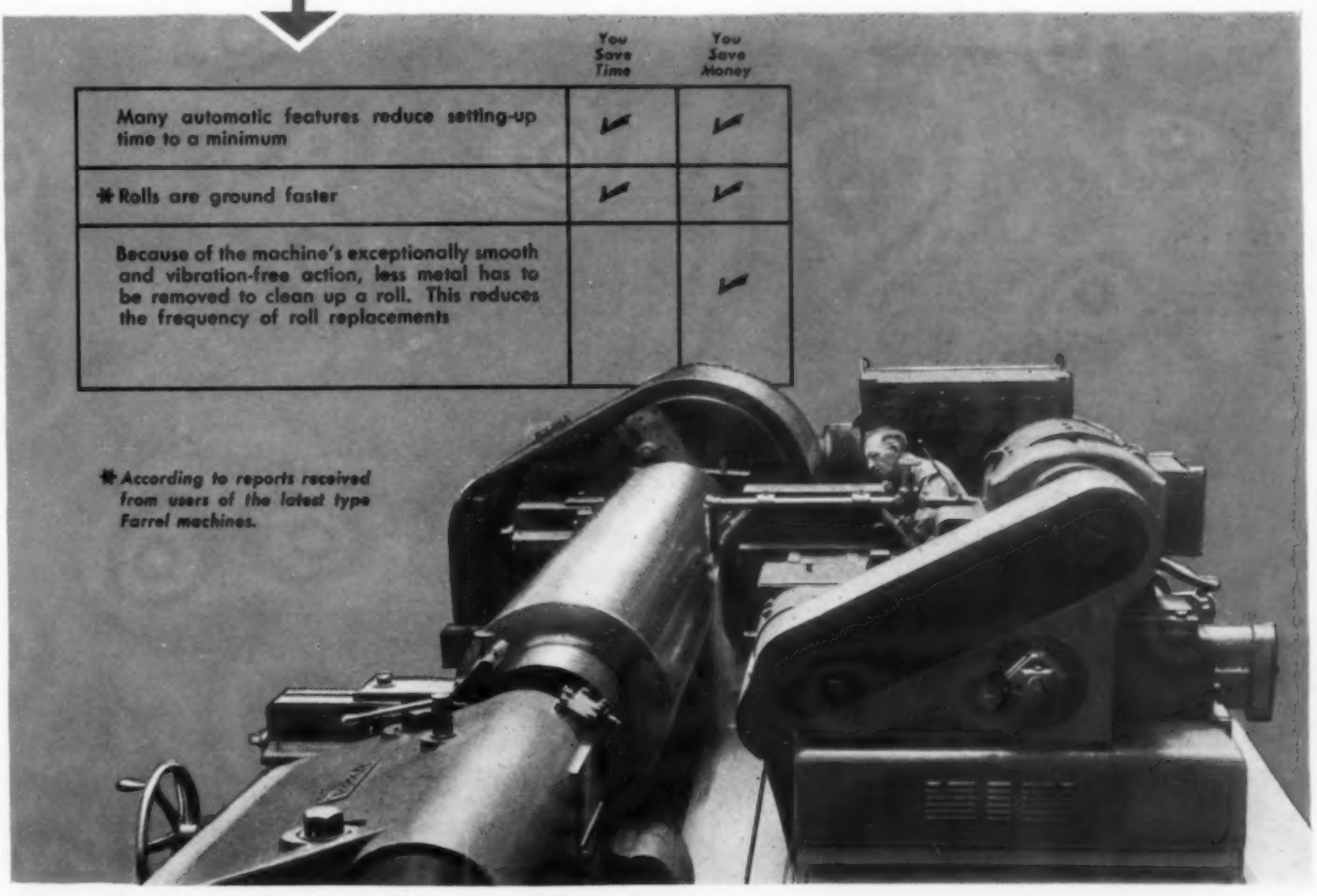
Plants: Ansonia and Derby, Conn., Buffalo, N. Y.
Sales Offices: Ansonia, Buffalo, New York, Pittsburgh, Akron, Chicago, Los Angeles, Houston

Farrel-Birmingham®

FB-799

	You Save Time	You Save Money
Many automatic features reduce setting-up time to a minimum	✓	✓
*Rolls are ground faster	✓	✓
Because of the machine's exceptionally smooth and vibration-free action, less metal has to be removed to clean up a roll. This reduces the frequency of roll replacements		✓

*According to reports received from users of the latest type Farrel machines.



AN ACCEPTED STANDARD FOR THE NEEDS OF INDUSTRY

Behind "Industrial" production you'll find modern equipment . . . engineering skill . . . craftsmanship . . . constant control . . . and large capacity.

We are specialists in cutting Gears, Sprockets, and Racks to serve machinery and equipment builders in all fields. Always specify "Durocase" Gears for Heavy-Duty or Steel Mill Service.

The quality we offer keeps assembly and maintenance costs low and assures dependable performance under the roughest conditions.

Send us your specifications for a prompt quotation on your requirements. Also write for Brochure "A Pictorial Trip Through Industrial."

Industrial Gear Mfg. Co.

4527 W. VAN BUREN ST.
CHICAGO 24, ILLINOIS

In the operation and maintenance of bearing, select the proper lubricant. In most cases the equipment manufacturer has recommended the lubricant found to have the necessary properties. Set up a regular maintenance and inspection schedule for all bearings and follow it closely. Keep your lubricant free of all foreign matter (you bought it that way) by using proper filtering and cleaning devices. Run the equipment at the speed and under the load for which it was designed.

BATTERY STORAGE

▲The following rules for proper storage of fully-charged wet batteries have been offered by K. A. Vaughan, manager, field engineering, Gould-National Batteries, Inc.:

Throughout industry, material handling supervisors, signal engineers and other plant executives occasionally find themselves stocked with a quantity of storage batteries which, for any of several reasons, cannot be put into immediate use. Such batteries can be stored, fully charged, without damage or deterioration if a simple program is put into effect and followed with regularity.

First, store such batteries in a cool, dry room where temperatures will not fall below 60 F or exceed 90 F. Do not stack the crates, but dispose them on the floor so that cells will be accessible for inspection and charging. Naturally, this arrangement will require that narrow aisles be provided for the sake of accessibility.

Tops should be removed from the shipping crates, and all excelsior or other packing material should be cleared away from around the tops of the cells. Once this is done, examine the cells for possible damage in shipment such as cracked jars or spillage. If any damage is apparent, notify the carrier immediately and have the necessary repairs or replacements made without delay.

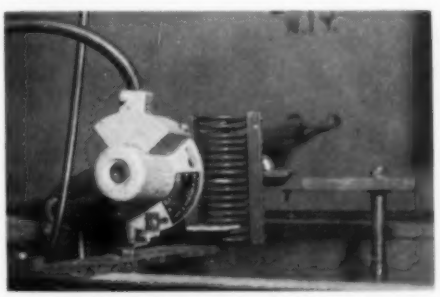
At 30-day intervals, take hydrometer readings of several cells; if any cell is found to read as low as 1.200 specific gravity, connect the cells in series (negative to positive) and then to a d-c source of current where a low rate of charge is available. Connect the positive terminal to the positive lead of the charging source and the negative terminal to the negative lead. Charge at the recommended finishing rate as indicated on the name plate or in the manufacturer's instructions until a constant voltage and specific gravity are obtained for four readings taken at hourly intervals and while the batteries are on charge.

In case the available charging equipment does not develop sufficient voltage to charge the entire battery at once, the battery may be split up into smaller units and each unit charged separately.

All specific gravity readings must be corrected for temperature. Correction of these readings for temperature is based on 77 F, with a correction factor of three points of gravity for each 10 F in acid temperature. Using 77 F as a base, add three points of gravity for each 10 F above base, and subtract three points for each 10 F below.

RAYOTUBE DETECTOR

▲An example of how modern industry is constantly doing things faster, more efficiently and more economically by imaginative application of long known principles was recently demonstrated by the Leeds & Northrup new high-speed small-target "Rayotube." By this development, the work of scientists for over fifty years in two separate fields of endeavor—induction heating and radiation pyrometry—was joined to give industry another new practical working tool.



Heat treating metal to alter its physical characteristics is one of industry's oldest and most basic processes. Heat treating metal by high-frequency electrical induction is one of the most effective methods of hardening, tempering, annealing, forging or brazing metal.

Measuring and controlling temperature during heat treating is essential to the manufacture of quality products. Accurately measuring and controlling temperature during induction heat treating has now become a practical reality.

As the use of induction heating grew, there was more and more demand for an accurate method of determining temperature during the heating cycle. Control of product temperature was usually determined by time or speed . . . in batch process by timing the length of the cycle . . . in continuous processes by controlling the speed at which work passed through the induction coils.

These methods, however, have serious limitations. Basically they rely on an indirect measurement. Any slight error in speed or time is amplified into many degrees of temperature error. The same thing is true for changes in conditions, such as fluctuating line voltage or frequency. Moreover the proper heating cycle for each different product must be determined by a tedious trial and error method and even then is not reproducible under changing conditions.

Recognizing this need of industry, Leeds & Northrup three years ago began work on a new "Rayotube" detector that could be applied to induction heating. Certain requirements had to be met. First, it must focus on the small area between the coils of an inductor so it could sight directly on the surface of the product being heated. It must respond in less than a second to the almost instantaneous temperature changes characteristic of induction heating. And it must be able to withstand high ambient temperatures, corrosive gases, etc., without losing accuracy or sensitivity.

The new detector can measure temperatures from 800 F up. Mounted four inches from the induction coil it can focus on an opening as small as 0.1 in. between turns of the coil and through this opening sights on the hot surface of the work. Its housing can withstand surrounding air temperatures up to 350 F. When suddenly exposed to radiation of a work piece, the detector will indicate 99 per cent of true temperature within 0.6 second. If temperature of the work is changing the temperature indicated by the Rayotube detector lags only 0.15 second behind that of the work. And finally, its optical system is hermetically sealed against dirt, dust and corrosive fumes.

The minute changes in radiation detected by the Rayotube are trans-

(*Please turn to Page 198*)

"The enthusiastic response of our employees . . ."

ALDEN G. ROACH
President, Columbia-Geneva Steel Division and Consolidated Western Steel Division, United States Steel Corporation

"It is most gratifying to me that the employees of the Columbia-Geneva Steel Division and the Consolidated Western Steel Division of United States Steel Corporation have accorded meaning to their belief that the security of our nation rests upon our cooperative effort. The enthusiastic response of our employees made me doubly glad we conducted a person-to-person canvass for the Payroll Savings Plan for U. S. Defense Bonds."

The experience of Columbia-Geneva and Consolidated Western Divisions of United States Steel Corporation is not an isolated one.

Since January 1, 1951, hundreds and hundreds of companies have conducted person-to-person canvasses of their plants and offices. In every instance, employee participation in the Payroll Savings Plan has increased—sometimes from a low figure—to 60, 70, 80%. In a number of plants, participation passed the 90% mark.

The explanation is simple.

Employees *want* to provide for their future security.

Given an opportunity to enroll in the Payroll Savings Plan they respond immediately—as evidenced by the fact that more than 2,000,000 men and women have joined the Payroll Savings Plan since January 1, 1951.

The monthly take-home savings of the 7,500,000 now in the Payroll Savings Plan totals $150,000,000 per month—and growing rapidly.

As a step toward *your* personal security, and the security of your associates, bring this page to the attention of your top executive. Tell him that—

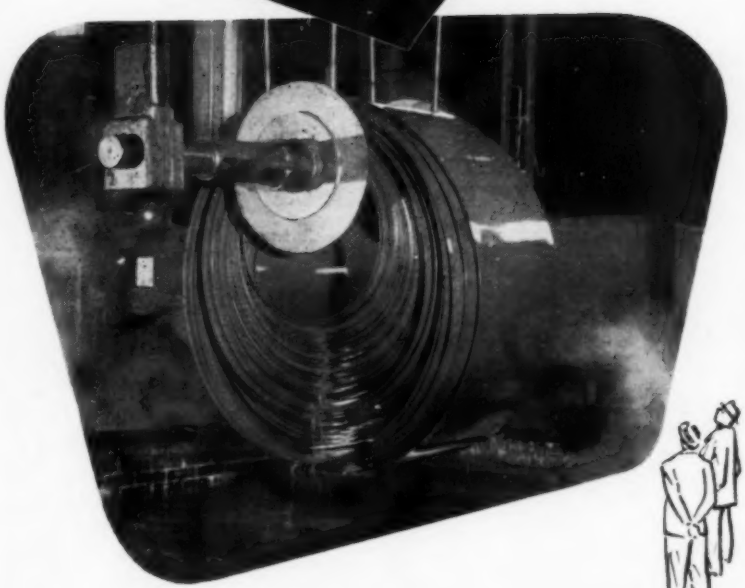
- a person-to-person canvass of your plant can be conducted without pressure, prize awards or other stimulation. (In many plants, employee organizations have undertaken the actual distribution of Payroll Savings Application Blanks.)
- The Savings Bond Division, U. S. Treasury Department, Suite 700, Washington Building, Washington, D. C., will gladly help your company with suggestions, posters, envelope stuffers and other aids.

The U.S. Government does not pay for this advertisement. It is donated by this publication in cooperation with the Advertising Council and the Magazine Publishers of America.

IRON AND STEEL ENGINEER

With a Low-Cost WELDCO Mechanical Coil Pickler Like This

You Get Uniform Pickling Like This



The new Weldco Mechanical Coil Pickler was designed especially for semi-continuous pickling in medium and low-tonnage mills. Economical and space-saving, it cuts manpower and maintenance expense to the minimum, while giving you thorough, uniform pickling in less time. For example—note the completely cleaned coil at the left, after processing in our McKees Rocks, Pa., installation. This 14-gauge steel was pickled *in 9 minutes* in a 12-14% sulphuric acid solution at 180°-200° F.

The Weldco unit assures efficient, inexpensive, individual coil pickling. Its flexibility permits you to pickle several different widths at the same time—eliminates down-time—resetting for size—hairpinning!

The Weldco Mechanical Coil Pickler is available in any capacity up to 25,000 tons per month, and with a small investment in handling equipment, can be used to pickle sheets, plates and bars. (For successful pickling of strip, a satisfactory scale breaker and loose coiler are required.) It will pay you to get complete details on this new, low-cost Weldco Pickler. Contact us for further information, and for complete engineering service on your entire pickling line.

THE YOUNGSTOWN WELDING & ENGINEERING COMPANY

3706 OAKWOOD AVENUE · · YOUNGSTOWN 9, OHIO

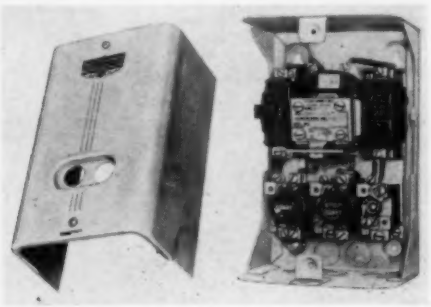
mitted to a "Speedomax" electronic recorder in the form of electrical millivoltage. This small electric current is amplified by the Speedomax instrument and automatically recorded on a chart calibrated in temperature degrees.

MAGNETIC UNIT

▲ Announcement is made by Cutler-Hammer, Inc., of a new line of magnetic starters, contactors and relays. This new line incorporates a simple 5 unit construction designed to install easier, work better, last longer. A wrap-around cover pulls off, fully exposing the front and both sides of the unit for 180 degree accessibility. The 5 independent parts consist of 2 contact blocks, a magnet coil, an armature and a 3-coil or 2-coil overload relay mounted on a steel panel. Each part can be removed from the front without disturbing another part.

The new line features a 3-coil, adjustable overload relay permitting 4 ratings from each heater coil by changing its position. This adjustability provides protection within 3 per cent of full load motor rating. The 3-coil overload offers better protection against single phasing where unbalanced or unstable line conditions may occur.

The double-break contacts, made of a special silver alloy, can be inspected by pulling off a snap-on cover; the contacts can be removed without tools. The complete contact block can be removed by loosening 2 screws; the overload relay by turning out 2 screws. The armature, which pivots on rolling bearings, and the magnet coil may be replaced easily without tools. The complete panel, with all units assembled, can be taken out of the metal case by loosening 3 screws.



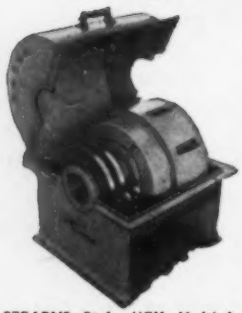
All terminals are angled to face front, and are equipped with solderless connectors that take a vice-grip on solid or stranded wire, or both, or wire of different sizes.

The cover and base are finished in grey enamel baked on bonderized metal.

AIR FILTER TESTER

▲ The definition of "How clean is really clean air" can now be determined by a new air filter testing device introduced by Trion, Inc. The new meter, known as the "Dill Dust-Spot Tester," is designed to accurately measure the efficiency of air filters on the job rather than in the laboratories of filter manufacturers. This new air filter tester is now commercially available, it provides a proven scientific method of obtaining factual, on-the-job, in-service data and efficiency ratings that are

Stearns KEEPS THEM ROLLING AT ALLEGHENY LUDLUM

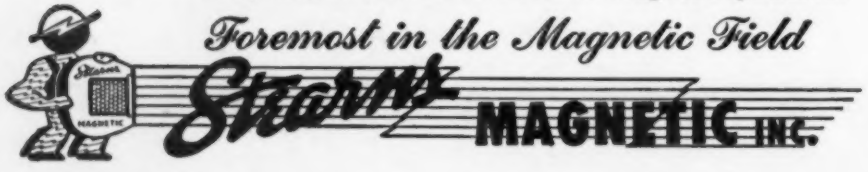


STEARNS Style "E" Multiple Disc Magnetic Clutch fully enclosed in steel housing for steel mill application.

Synchronizing the drives of the screwdowns of a large mill requires a rugged, dependable clutch — a STEARNS Multiple Disc Magnetic Clutch. That's exactly the story of this installation, told four times! On each stand of this Mesta four high cold rolling mill at the Allegheny Ludlum Steel Corp., West Leechburg, Pa., there is a STEARNS Magnetic Clutch to synchronize the screwdown drives.

The newest and most powerful for its size, it is natural that this strip mill incorporate STEARNS Magnetic Clutches. Designed for just such steel mill applications, the STEARNS clutch is a low inertia unit of simple construction with no toggles, pins, yokes, shifters or other parts to wear and get out of order. Controlled by a push-button station, STEARNS clutches are available with taper-bores, detachable magnet hub, torques and construction to meet your screwdown requirements.

STEARNS EQUIPMENT FOR STEEL MILLS

Circular and Rectangular Lifting Magnets
Sheet and Pipe Conveyor Rolls
Magnetic Brakes and Clutch-Brakes
Drag Magnets and other steel mill magnetic specialties

681 South 28th Street • Milwaukee 46, Wisconsin

POOLE

A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY

WOODBERRY, BALTIMORE, MD.

The burner block is the heart of your fuel-fired furnace

TASIL Burner Block installed in a No. 225-4 Dual Fuel Burner of the North American Manufacturing Co., Cleveland, Ohio, leading producers of industrial fuel-burning equipment. TASIL Burner Blocks are standard equipment on North American burners for high temperature applications.

The better burner block is TAYLOR SILLIMANITE!

PRE-FIRED BURNER BLOCKS of Taylor Sillimanite (TASIL) are preferred by North American and a majority of leading furnace and burner manufacturers for high temperature applications. TASIL is specified because the block must hold original contour and dimensions. Compared to blocks made of fireclay or most other refractory materials, TASIL has superior resistance to shrinkage, cracking or spalling. TASIL further qualifies because it is inert in either oxidizing or reducing atmospheres; has higher fusion point and resistance to corrosion by most industrial slags. For longer service from your heating, annealing or forging furnaces, specify TASIL burner blocks.

In an emergency, when a burner block failure occurs at the time your stocks of pre-fired shapes are depleted, you can ram your own TASIL Burner Blocks, on the job, with one of several TASIL Ramming Mixes *engineered* for this application. Burner Blocks which may be cast or poured in molds, air dried and placed in service can also be made from TASIL Hydrocast—the hydraulic-setting castable for use to 3000° F. Data on TASIL Ramming Mixes are given in Bulletin No. 315 . . . on TASIL Hydrocast, Bulletin No. 313. Write direct, or contact your Taylor field representative, for your free copies.

Exclusive Agents in Canada:
REFRACTORIES ENGINEERING AND SUPPLIES, LTD.
Hamilton and Montreal

TAYLOR ZIRCON · TAYLOR SILLIMANITE

The CHAS. TAYLOR SONS Co.
A SUBSIDIARY OF NATIONAL LEAD COMPANY
REG. U. S. PAT. OFF.
REFRACTORIES SINCE 1864 • CINCINNATI • OHIO • U. S. A.

comparable for all types of air filters and air cleaners.

The apparatus consists essentially of drawing samples of dirty and

cleaned air through filter paper. The efficiency of a filter is determined by the amount of light transmitted through the filter paper; measured by photoelectric instruments.

SINGLE PHASE MOTOR

▲A new development in single phase variable speed motors in fractional horsepower is announced by U. S. Electrical Motors, Inc. As a modification of the company's Type VA "Varidrive" line, the new motor permits use of 110 or 220 volts. It is designated as Type VA-C and is made in ¼,—½ and ¾ hp. This compact, lightweight motor provides speeds in a 10:1 ratio with the range from 4 to 10,000 rpm. Merely by turning a con-

venient control dial, the motor's speed can be instantly changed to a desired speed without stopping. It eliminates the necessity of an external speed changing device or gear box and occupies little more room than a standard fixed speed motor.

HARD-FACING ALLOY

▲ Superior resistance to abrasion at high temperatures, the ability to withstand attack by molten copper and improved welding characteristics are some of the important advantages offered by CM-199, a new hard-facing alloy manufactured by Coast Metals, Inc.

Because of its ability to resist abrasion at the temperature of hot-rolled steel, the new alloy has already found successful application as hard facing for large guide rolls and as hot friction guides and soaking tong bits. And its resistance to attack by molten copper permits the alloy to yield excellent results as protection for the lips of copper converters.

The alloy can be applied with any good arc welding process. It has easy welding characteristics that assure efficient bonding. It will weld over itself and more ferrous materials without cracking, checking or parasity—a fact which permits patching where previously full replacement has been necessary. This and the longer service life that result from superior abrasion resistance make the alloy exceedingly economical both for initial hard facing and subsequent rebuilding.

FLEXIBLE COUPLING

▲ A new modification of the Lovejoy Flexible Coupling Co. Type C coupling can literally be described as one which "crawls into the flywheel." Economical in cost, as well as in space required, it is a standard Type C coupling with one hub cut off. Three or more holes are tapped in the remaining flange, by which the coupling is fastened to the center of the flywheel.

Thus by "crawling" into the flywheel itself, this modified coupling not only saves the space normally taken up by conventional hub-length, but also affords a cost savings over standard flywheel couplings in

the elimination of the flange. In all other respects, including collar, load cushions and inside sleeve, it is identical with the regular Type C Coupling.

COIL-HANDLING TONGS

These husky but gentle coil-handling tongs are located at the Gary, Ind., sheet and tin mill of the United States Steel Co. Designed by Heppenstall Co. they'll pick up coils of strip steel as heavy as 70,000 lb and carry them safely, without malforming the coils or damaging the edges of the strip. The illustration shows another coil being lowered into position on an annealing furnace base. When the coil is safely in position, lowering the tongs will lock them in the open position again, making them ready for another job. Safety is assured, as the entire operation is under control of the craneman, with no need for a ground crew to fasten or unfasten the burden.

BLOWER

▲ New large volume blowers, designed for economy of operation and maintenance, have been added to the already extensive line of North American Manufacturing Co. Series 300 turbo blowers.

With motor speeds of 1750 rpm, blowers are available which deliver up to 4700 cfm at 4 oz pressure, or 4800 cfm at 8 oz pressure. At motor speeds of 3500 rpm the blowers range up to 7560 cfm at 16 oz pressure.

"she might have been my kid..."

"There was no time to stop, see? She comes running out from behind this parked car right under my wheels. Her hair is in pigtails, and with the sun shining on it, she might have been *my* kid. We got her to the hospital. It took 3 pints of blood to bring her around. All I have to do is remember the sound of those screaming tires—and I know why *I'm* giving blood."

Yes, all kinds of people give blood—truck drivers, office workers, salesmen. And—for all kinds of reasons. But whatever *your* reason, this you can be sure of: Whether your blood goes to a local hospital, a combat area or for Civil Defense needs—this priceless, painless gift will some day save an American life!

Business Executives! ✓Check These Questions!

If you can answer "yes" to most of them, you—and your company—are doing a needed job for the National Blood Program.

- ☐ Have you given your employees time off to make blood donations?
- ☐ Has your company given any recognition to donors?
- ☐ Do you have a Blood Donor Honor Roll in your company?
- ☐ Have you arranged to have a Bloodmobile make regular visits?
- ☐ Has your management endorsed the local Blood Donor Program?
- ☐ Have you informed your employees of your company's plan of co-operation?
- ☐ Was this information given through Plant Bulletin or House Magazine?
- ☐ Have you conducted a Donor Pledge Campaign in your company?
- ☐ Have you set up a list of volunteers so that efficient plans can be made for scheduling donors?

Remember, as long as a *single* pint of blood may mean the difference between life and death for *any* American . . . the need for blood is *urgent!*

Give Blood Now

CALL YOUR RED CROSS TODAY!

NATIONAL BLOOD PROGRAM

Applications for AISE Membership

Active

M. DONALD BLASIER
Assistant Plant Superintendent
Pittsburgh Steel Co.
Thomas Strip Division
Warren, Ohio

ALFRED W. BLUMBERG
Maintenance Superintendent
Armco Steel Corp.
Rustless Division
Baltimore, Md.

JOHN F. BOAL
Lubrication Engineer, Maintenance Committee
U. S. Steel Corp.
Pittsburgh, Pa.

LEWIS A. BOORE
Field Engineer, Erection Department
Bethlehem Steel Corp.
Pottstown, Pa.

W. J. BURCHAM
Superintendent Rolling Mills
Sheffield Steel Corp.
Sand Springs, Okla.

HARRY F. BRINKER
Superintendent Heat Treating and Forge
U. S. Steel Corp.
Homestead Works
Homestead, Pa.

RUBERT CAPLEY
Assistant Chief Engineer
Steel and Tube Division
Timken Roller Bearing Co.
Canton, Ohio

GEORGE CLIM
Assistant to Chief Engineer
Dominion Foundries Steel, Ltd.
Hamilton, Ontario, Canada

WILLIAM A. COLLINS
General Supervisor Fuel and Power Distribution
U. S. Steel Corp.
Gary, Ind.

M. J. COOPER
Superintendent of Hot Mill
Dominion Foundries & Steel, Ltd.
Hamilton, Ontario, Canada

JOHN C. COPPICK
General Manager
Canadian Steel Corp., Ltd.
Ojibway (Essex County), Ontario, Canada

F. E. DAVIS
Design Engineer, Gary Steel Works
U. S. Steel Corp.
Gary, Ind.

CHARLES R. DAY
Assistant Plant Engineer
A. M. Byers Co.
Ambridge, Pa.

C. J. DENTZER
Supervisor Engineering and Maintenance
American Steel & Wire Division
U. S. Steel Corp.
Cleveland, Ohio

P. H. DEVANEY
Works Manager, Aliquippa Works
Jones & Laughlin Steel Corp.
Aliquippa, Pa.

CHARLES K. DEVINE
Junior Engineer
Inland Steel Co.
East Chicago, Ind.

BAXTER DICK
Plant Engineer
Page-Hersey Tubes, Ltd.
Welland, Ontario, Canada

RUBEN FINKELSTEIN
Vice President
Southwest Steel Rolling Mills, Inc.
Los Angeles, Calif.

H. KERMIT FISH
General Electrical Foreman
Strip Steel & S. M. Department
Weirton Steel Co.
Weirton, W. Va.

C. H. FITZWILSON
Chief Metallurgical Engineer
Columbia-Geneva Steel Division
U. S. Steel Corp.
Russ Building
San Francisco, Calif.

JAMES F. FRANEY
Roller
American Steel & Wire Division
U. S. Steel Corp.
Cleveland, Ohio

E. V. FRANKHOUSER
Superintendent of Power
Alan Wood Steel Co.
Conshohocken, Pa.

D. G. FRASER
Superintendent Bar and Strip Mill
Algoma Steel Corp.
Sault Ste. Marie, Ontario, Canada

HAROLD G. FROSTICK
Design Engineer
U. S. Steel Corp.
Pittsburgh, Pa.

MARTIN S. GETTIG
Superintendent Seamless Tube Mills
Youngstown Sheet & Tube Co.
Youngstown, Ohio

GROVE R. GINDER
Assistant Plant Industrial Engineer
U. S. Steel Corp.
Gary Steel Works
Gary, Ind.

G. RAYMOND GOSS
Rolling Turn Foreman 98 in. Hot Mill
Republic Steel Corp.
Cleveland, Ohio

W. D. GROVE
Design Engineer
U. S. Steel Corp.
Pittsburgh, Pa.

H. V. HAGBORG
Senior Draftsman
Atlas Steels Ltd.
Welland, Ontario, Canada

STANLEY W. HALL
Supervisor Employer Services
Industrial Relations Department
Ford Motor Co.
Dearborn, Mich.

E. J. HANLEY
President
Allegheny Ludlum Steel Corp.
Pittsburgh, Pa.

GLEN W. HARMON
Maintenance Superintendent
McLouth Steel Corp.
Detroit, Mich.

OWEN C. HASSELL
Assistant Superintendent Mechanical and Electrical
Tennessee Coal & Iron Division
U. S. Steel Corp.
Ensley, Ala.

JOHN A. HEIDISH
Superintendent Casting, Rolling
Copperweld Steel Co.
Glassport, Pa.

I. J. HETHERINGTON
General Supervisor, Maint. Planning Office
U. S. Steel Corp.
Fairless Works
Morrisville, Pa.

J. ERNEST HILL
Superintendent Fairfield Tin Mill
Tennessee Coal & Iron Division
U. S. Steel Corp.
Birmingham, Ala.

EDMUND B. HOGUE
Assistant to Works Engineer
The Midvale Co.
Philadelphia, Pa.

EDWARD G. HURL
Plant Manager
Follansbee Steel Corp.
Follansbee, W. Va.

W. J. INGOLDSBY
Assistant to Chief Engineer
Lloyd E. Mitchell Co.
Baltimore, Md.

LAMBERT R. JOHNSON
Assistant Division Engineer—Projects
American Steel & Wire Division
United States Steel Corp.
Cleveland, Ohio

JOHN D. JUDGE
President
Tube Reducing Corp.
Wallington, N. J.

FRANK A. KELLY
Plant Industrial Engineer
U. S. Steel Corp.
Gary Steel Works
Gary, Ind.

K. J. KENYON
Project Engineer
Algoma Steel Corp.
Sault Ste. Marie, Ontario, Canada

LAMSON KERINS
Assistant General Transportation Manager
U. S. Steel Corp.
Pittsburgh, Pa.

A. F. LaFORCE
Assistant Superintendent Mechanical Operations
U. S. Steel Corp.
Power Division
Chicago, Ill.

WILLIAM D. LAMONT
General Superintendent
Dominion Foundries & Steel Ltd.
Hamilton, Ontario, Canada

GEORGE L. LANE, JR.
Assistant General Maintenance Foreman
Jones & Laughlin Steel Corp.
Aliquippa, Pa.

ROLAND C. LANEY
Superintendent, Utilities
U. S. Steel Corp.
Fairless Works
Morrisville, Pa.

ROBERT LEISHMAN
Superintendent Cold Roll & Tin Plate Dept.
Dominion Foundries & Steel Ltd.
Hamilton, Ontario, Canada

MYRON W. LEWIS
Chief Industrial Engineer
U. S. Steel Corp.
Pittsburgh, Pa.

THOMAS W. LEWIS
Assistant Division Superintendent Structural Mills
U. S. Steel Corp.
Homestead Works
Munhall, Pa.

WILLIAM M. LEWIS
Master Mechanic, Tin, Sheet and Strip Mills
Bethlehem Steel Corp.
Sparrows Point, Md.

VICTOR H. LINDBERG
Superintendent 43 in. Primary Rolling and Conditioning Department
U. S. Steel Corp.
Ohio Works
Youngstown, Ohio

CARL L. LINDQUIST
General Foreman Electrical Repair Shop
U. S. Steel Corp.
Gary, Ind.

R. W. LISTER
Niagara District Sales Office Manager
Canadian Westinghouse Co., Ltd.
Hamilton, Ontario, Canada

MAXIMILLIAN LOBLEY
President
Lobley Machine Works, Inc.
Brooklyn, N. Y.

JOHN W. LOGAN, JR.
General Supervisor-Construction Engineer
U. S. Steel Corp.
Edgar Thomson Works
Braddock, Pa.

ARNOLD LONGLEY
Manager of Training
Atlas Steels Ltd.
Welland, Ontario, Canada

JOHN F. McCORKINDALE
Lubricants Engineer
Shell Oil Co.
Birmingham, Ala.

ROGERS A. McDUFFIE
General Foreman Brickmasons
Tennessee Coal & Iron Division
U. S. Steel Corp.
Ensley, Ala.

E. E. McGINELY
Division Superintendent
Open Hearth and Foundry
U. S. Steel Corp.
Homestead Works
Munhall, Pa.

THOMAS E. McHALE
Mechanical Engineer
Freyn Engineering Department
Koppers Co., Inc.
Chicago, Ill.

C. R. McLEOD
Assistant Superintendent Cold Strip Mill
Inland Steel Co.
East Chicago, Ind.

H. W. MAURICE
Contract Engineer
Freyn Engineering Department
Koppers Co., Inc.
Chicago, Ill.

ROBERT A. MERCK
Specialty Engineer
Freyn Engineering Department
Koppers Co., Inc.
Chicago, Ill.

C. H. MERKL, JR.
Electrical Foreman
Tennessee Coal & Iron Division
U. S. Steel Corp.
Fairfield, Ala.

WILLIAM R. METZ
Application Engineering Manager
Westinghouse Electric Corp.
Canton, Ohio

GEORGE R. MICHELIN
Assistant Contract Engineer
Freyn Engineering & Construction Division
Koppers Co., Inc.
Chicago, Ill.

WILLIAM D. MILLAR
Division Superintendent Blast Furnace
U. S. Steel Corp.
Chicago, Ill.

HAROLD R. MILLER
General Foreman, Assigned Maintenance Dept.
Armco Steel Corp.
Butler, Pa.

WALTER C. MILLER
General Electrical Foreman
Republic Steel Corp.
Cleveland District Works
Cleveland, Ohio

CLARENCE R. MITCHELL
Superintendent 48 in. Hot Strip Mill
Fairfield Tin Mill

Tennessee Coal & Iron Division
U. S. Steel Corp.
Fairfield, Ala.

R. C. MOFFITT
Director of Purchases
U. S. Steel Corp.
Pittsburgh, Pa.

GREGORY R. MOLINARO
General Supervisor Maintenance Development
U. S. Steel Corp.
Gary Steel Works
Gary, Ind.

HENRY C. MULLINS
Senior Engineer Fuel Department
Bethlehem Steel Corp.
Lackawanna, N. Y.

GEORGE R. MURPHY
Design Draftsman
Continental Foundry & Machine Co
Pittsburgh, Pa.

JOSEPH I. NADEAU
Assistant General Foreman
U. S. Steel Corp.
Gary Steel Works
Gary, Ind.

VINCENT W. NORAKO
Application Engineer
Westinghouse Electric Corp.
Detroit, Mich.

JOHN W. OGLETREE
Chief Draftsman
Tennessee Coal & Iron Division
U. S. Steel Corp.
Birmingham, Ala.

DON R. O'HARA
District Engineer
Falk Corp.
Philadelphia, Pa.

EMIL A. OSBERG, JR.
Layout Draftsman
Freyn Engineering Division
Koppers Co., Inc.
Chicago, Ill.

J. R. PAISLEY
Vice President and General Manager
Wean Equipment Corp.
Euclid, Ohio.

WALLACE J. PIGGOTT
Partner
P. M. Kline and Associates
Cleveland, Ohio.

CHARLES M. RADER
Sales Engineer
Treadwell Construction Co.
Midland, Pa.

ROBERT F. RICE
Manager, Materials Handling Department
Harvey, Ill.

SCOTT F. ROST
Sales Engineer
New York Blower Co.
Chicago, Ill.

FREDERICK W. RYS
Operating Manager
Freyn Engineering Department
Koppers Co., Inc.
Chicago, Ill.

A. C. SCHETTLER
Sales Engineer
Reliance Electric & Engineering Co.
York, Pa.

A. DEAN SMITH
Chief Engineer of Fabricating Division
Kaiser Aluminum and Chemical Corp.
Oakland, Calif.

EDWARD P. SMITH
Design Engineer
General Electric Co.
Schenectady, N. Y.

SELWYN V. STICKLER, JR.
Consulting & Application Engineer Steel Mills
Westinghouse Electric Corp.
Philadelphia, Pa.

G. C. A. SWANSON
Development Engineer
Lake Erie Engineering Corp.
Buffalo, N. Y.

JOHN WILLIAM SWIFT
Assistant Chief Engineer
Aluminum Laboratories, Ltd.
Montreal, Quebec, Canada.

E. W. TAYLOR
President
S. G. Taylor Chain Co.
Hammond, Ind.

LESLIE A. WEST
Supervisor — Mill Electrification Section
Westinghouse Electric International Co.
New York, N. Y.

JAMES WINDROSS
Plant Engineer
Reynolds Metals Co.
Brookfield, Ill.

GEORGE H. WROCKLAGE
Sales Engineer (Eastern Territory)
Bedford Foundry & Machine Co.
Bedford, Ind.

Associate

JAMES R. ADAIR
Engineer
United Engineering & Foundry Co.
Pittsburgh, Pa.

LEONARD W. ADAMS
District Manager, Mechanical Goods Division
Goodyear Tire & Rubber Co.
Akron, Ohio

EDWIN S. BANTA
Sales Engineer
Laurel Building Products Co.
Philadelphia, Pa.

FLOYD BLAINE, JR.
Engineer
Western Brass Mills
East Alton, Ill.

JOHN W. COULTON
Partner
H. F. Black Equipment Co.
Cleveland, Ohio

BARTEL JOHN DISANTO
Chief Engineer, Primary Smelters and Refineries
American Smelting & Refining Co.
Salt Lake City, Utah

JAMES W. DOLL
Vice President
Northwest Sales, Inc.
Detroit, Mich.

FRANCIS E. FAIRMAN, III
Steel Mill Application Engineer
General Electric Co.
Schenectady, N. Y.

JOHN M. FETHERSTON
District Manager
Photostat Corp.
Pittsburgh, Pa.

JOHN GROSS
Chief Estimator
E. W. Bliss Co.
Salem, Ohio

ROBERT GUBBINS
Process Engineer
Quaker Chemical Products, Inc.
Detroit, Mich.

CRAWFORD HAYES
Maintenance Engineer
Bridgeport Brass Co.
Indianapolis, Ind.

CALVIN A. HOERNEMAN
Sales Engineer
Bloom Engineering Co., Inc.
Pittsburgh, Pa.

OTTO HOFFMANN
Vice President — Charge of Engineering
Lake Erie Engineering Corp.
Buffalo, N. Y.

JOHN W. HOLZWARTH
Sales Engineer
Salem Engineering Division
Salem-Brosius, Inc.
Salem, Ohio.

LOUIS W. HORVATH
Sales Manager
Flinn & Dreffein Engineering Co.
Chicago, Ill.

R. E. HUNTER
Partner
H. F. Hunter Sales
Pittsburgh, Pa.

CARL E. JOHNSON
Sales Engineer
Jesse W. Eakins Co.
Detroit, Mich.

ARNOLD J. KARSTEN
Specialty Sales Manager
Freyn Engineering Department
Koppers Co., Inc.
Chicago, Ill.

FREDERICK J. KENLINE
Assistant Chief Engineer
Lake Erie Engineering Corp.
Buffalo, N. Y.

K. J. KETTNER
Sales Engineer
The Ramtite Co.
Chicago, Ill.

C. A. KISSINGER
Salesman
Johns-Manville Sales Corp.
Baltimore, Md.

M. W. KITZMILLER
Manager, D-C Armored Motor Engineering
General Electric Co.
Erie, Pa.

M. E. KNUDSON
Manager — Steel Mill & Metal Working Section
Westinghouse Electric Corp.
East Pittsburgh, Pa.

GEORGE L. LANGRETH
Vice President Finance
Blaw-Knox Co.
Pittsburgh, Pa.

JOHN R. LEES
Field Application Engineer
I-T-E Circuit Breaker Co.
Philadelphia, Pa.

J. R. LOTTES
Sales Representative
American Brake Shoe Co.
National Bearing Division
Cleveland, Ohio

ROSS B. McCREADY
Structural Engineer
Alliance Machine Co.
Alliance, Ohio

WALTER W. MacCALLUM
Manufacturers Representative
Philadelphia, Pa.

WILHELM MASGEIK
Chief Engineer
Demag Aktiengesellschaft
Duisburg, Germany

CLARENCE A. NORDSTROM
Sales Engineer
Thomas Pump Co.
Chicago, Ill.

WALTER R. O'MALLEY
Sales Representative
Harnischfeger Corp.
Philadelphia, Pa.

J. A. RENTON
Purchasing Agent and Traffic Manager
Lombard Corp.
Youngstown, Ohio.

WILLIAM C. RHINE
Electrical Engineer
Cutler-Hammer, Inc.
Milwaukee, Wisc.

OTTO G. SCHWENK
Vice President Industrial Products
Blaw-Knox Co.
Pittsburgh, Pa.

FREDERICK E. TERRY
Representative
Tool Steel Gear & Pinion Co.
Cincinnati, Ohio.

WILLIAM E. WARGO
Sales Engineer
Federal Electric Products Co.
Newark, N. J.

HAROLD E. WILLS
Cleveland Manager
Ingersoll-Rand Co.
Cleveland, Ohio.

Junior

RALPH E. BAILEY
Open Hearth Engineer
Ford Motor Co.
Dearborn, Mich.

WILLIAM A. BRINGMAN
Materials Engineer, Steel Division
Ford Motor Co.
Dearborn, Mich.

EDGAR W. HUNTER
Management Candidate Engineer Trainee
United States Steel Co.
Pittsburgh, Pa.

JOSEPH LA PORTE, JR.
Engineer Trainee
United States Steel Co.
Pittsburgh, Pa.

KENNETH L. MINNICK
Engineering Trainee
United States Steel Co.
Pittsburgh, Pa.

EARL C. NEFF
Production Process Analyst
Ford Motor Co.
Dearborn, Mich.

PAUL P. OHMER, JR.
Engineering Trainee
United States Steel Co.
Pittsburgh, Pa.

EDWARD FRANCIS PHIPPS
Steel Plant Draftsman
Alan Wood Steel Co.
Conshohocken Pa.

WALTER J. TILL
Engineering Trainee
Manufacturing Division
United States Steel Co.
Pittsburgh, Pa.

Roll More Tons per pass with PARALLOY

REGISTERED TRADE-MARK

The Quality Name in

PINCH ROLLS
COILER ROLLS
TENSION ROLLS
STEEL MILL ROLLS

No Scratching or Galling
500-600-BRINELL

Also Makers of

DUCTILE IRON

... A Recent and Revolutionary development in the casting industry.

Other Y&M Products

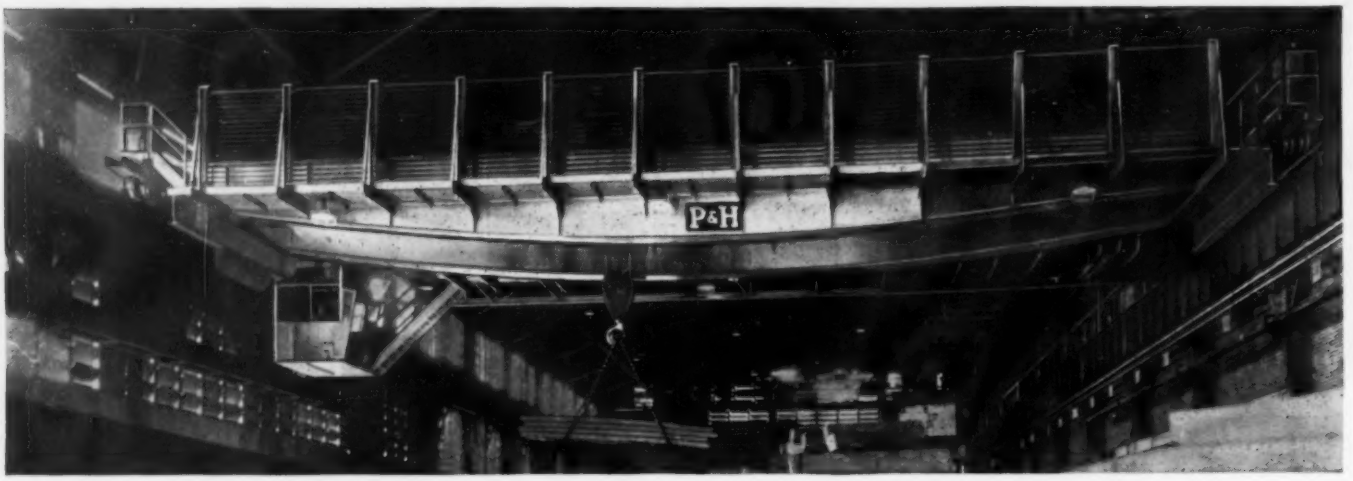
- HYDRAULIC SLAB AND BILLET PILERS
- STRIP AND SHEET OILING EQUIPMENT
- SHEET SCRUBBER AND CLEANING LINES
- HOT SAWS—ROCKING AND SLIDE TYPES
- HOT BEDS—COOLING BEDS—TRANSFERS
- BILLET EJECTORS—PINCH ROLL STANDS
- SLITTERS—SPECIAL SHEARS AND GAUGES
- TILTING TABLES—TRAVELING AND LIFTING TABLES
- CONTINUOUS PICKLING LINES—ROLLER LEVELLERS
- FURNACE CHARGING EQUIPMENT—FURNACE PUSHERS
- STRIP STEEL COILERS AND REELS—SCRAP BALLERS
- RAILROAD SPIKE FORMING MACHINES—ROLL LATHES
- SHEET GALVANIZING LINES WIRE PATENTING FRAMES
- STRETCHER LEVELLERS—ANGLE AND SHAPE STRAIGHTENERS
- ROLLING MILL TABLES—GEAR AND INDIVIDUAL MOTOR TYPES
- MACHINERY BUILT TO CUSTOMER'S DESIGN AND DETAIL DRAWINGS

The Youngstown Foundry & Machine Co.

OVER SIXTY YEARS OF SERVICE TO THE STEEL INDUSTRY

Youngstown, Ohio

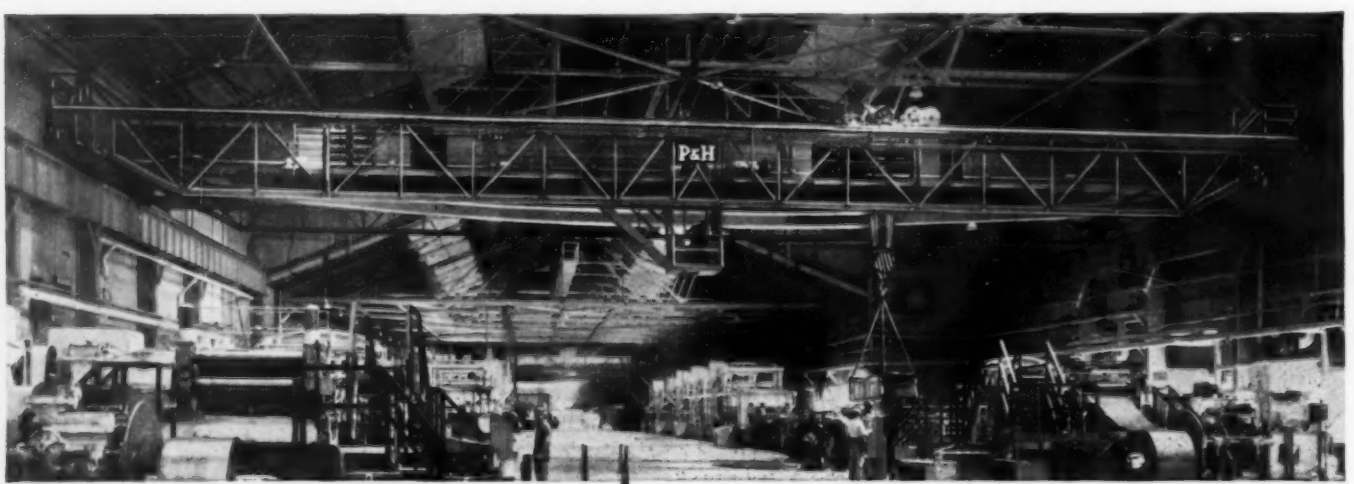
NORTH..SOUTH..EAST..WEST..EVERYWHERE!



P&H

STEEL MEN PREFER
MILL TYPE CRANES
for longer, finer service

Now, the number is well over the 2000 mark — more and more P&H Cranes serving the steel industry. There's good reason for the preference steel men put in P&H . . . and that is *performance*. It's measured in longer years of service, in lower costs, in more dependable operations. Learn more about P&H Mill Type Cranes. Write for your copy of Bulletin C-42.



P&H ***...ahead in added values***

3-Gear Case Bridge Drive — for perfectly equalized motive power.

No Open Gears at Trucks — gear reductions are fully enclosed, running in oil.

Flexible Couplings at Wheel Shafts — for smoother starts, longer bearing life.

Split Gear Cases — easier inspection and maintenance.

Large Diameter Cross Shaft — greater strength, lower torque to minimize strain.

Hoist Sheaves — readily accessible from trolley deck. All hoist gears, including drum gear and pinion, run in oil.

P&H Motors, brakes and controls available.

P&H **OVERHEAD CRANE DIVISION**

HARNISCHFEGER
CORPORATION

4400 West National Avenue, Milwaukee 46, Wisconsin

POWER SHOVELS • CRAWLER AND TRUCK CRANES • OVERHEAD CRANES • HOISTS • ARC WELDERS AND ELECTRODES • SOIL STABILIZERS • DIESEL ENGINES • PRE-FAB HOMES

THE ENGINEERING MART

WHERE TO BUY
EQUIPMENT FOR SALE
POSITIONS VACANT
POSITIONS WANTED

AN *IRON and STEEL ENGINEER* SERVICE TO THE STEEL MILL OPERATORS

WHERE TO BUY

BIRMINGHAM DISTRICT

DIXIE ENGINEERING COMPANY
"Manufacturer's Agents"
P. O. Box 750 — 814 Protective Life Building
BIRMINGHAM 3, ALABAMA
Sabel E. Baum — Telephone 7-6376

CHICAGO DISTRICT

PAUL W. WENDT & SONS
Manhattan Building
CHICAGO 5, ILLINOIS
District Representatives for
A. W. CADMAN MFG. CO.
HUNTER SAW & MACHINE CO.
GRAFO COLLOIDS CORP.

EHRET AND KINSEY
Board of Trade Bldg., 141 West Jackson Blvd.
Chicago 4, Illinois — Wabash 2-0449
Representing
THE CLEVELAND WORM AND GEAR CO.
Worm Gearing and Worm Gear Speed Reducers
THE FARVAL CORPORATION
Farval Centralized Lube Systems
LUBRICATION PRODUCTS COMPANY
Stapax Journal Box Lubricators
AMERICAN FLEXIBLE COUPLING COMPANY
Amerigear Flexible Couplings
WALDES KOHINOOR, INCORPORATED
Truarc Retaining Rings

PHILADELPHIA DISTRICT

TOWLE & Son Co.
18 West Chelton Ave. — GE 8-1930
PHILADELPHIA 44
Representing:
THE TOOL STEEL GEAR AND PINION CO.
Cincinnati 16, Ohio

PITTSBURGH DISTRICT

ROLLING MILLS and EQUIPMENT
FRANK B. FOSTER, INC.
2220 OLIVER BUILDING PITTSBURGH 22, PA.
Cable Address "FOSTER" Pittsburgh

BLAST FURNACE
CONTRACTORS
• Construction • Rebuilds • Linings
• Maintenance • Repair
AFFILIATED FURNACE, INC.
4064 Penn Avenue, Pittsburgh 24, Pa.

METALLIC RECUPERATORS
(Air Preheaters)
For application to soaking pits, heating, and other types of metallurgical furnaces.
HAZEN ENGINEERING CO.
Park Building — PITTSBURGH, PA.
COurt 1-7032

PATTERSON-EMERSON-COMSTOCK, INC.
ENGINEERS AND CONSTRUCTORS
Specializing in Steel Mill Construction
313 E. Carson Street
Pittsburgh 19, Pa.
Phone: EVerglade 1-9800

Auburn & Associates, Inc.
Engineers
ELECTRICAL LAYOUTS FOR STEEL MILLS
923 Penn Ave., Pgh. 22, Pa.
Telephone COurt 1-5014

W. G. KERR CO., INC.
520 Oliver Building — PITTSBURGH, PA.
Phone: ATlantic 1-4254
Representing:
FOOTE BROS.—Gears and Speed Reducers
REEVES—Variable Speed Drives
THOMAS—Flexible Couplings
WICHITA—Air Tube Disc Clutches & Brakes
TELSMITH—Telsmith Crushers
CULLEN-FRIESTEDT—Sheet Lifters—Welding Positioners—Track Cranes

PITTSBURGH (Continued)

CHEMSTEEL CONSTRUCTION COMPANY, INC.
204 Chemsteel Bldg., Walnut St., Pittsburgh 32, Pa.
Send data on Engineering & Construction facilities for
ACID-ALKALI-PROOF CONSTRUCTION
of pickling and other tanks; flooring.
(TEAR OUT & MAIL WITH LETTERHEAD)

RITTER ENGINEERING CO.
Engineers - Distributors - Contractors
1515 WEST LIBERTY AVE. — Phone:
PITTSBURGH 26, PA. — LOCUST 1-1303
Representing:
TRABON ENGINEERING CORP.
"Centralized Lubricating Systems"

CONSULTING ENGINEERS

LOYAL R. MILBURN
Consulting Electrical Engineer
Registered State of Michigan
1928 Guardian Building • Detroit 26, Michigan
Telephone: Woodward 3-8706 or
Whitmore Lake 5141

LOEDDING ENGINEERING CO., INC.
CONSULTING, DESIGN AND DETAIL
Industrial and Commercial Planning
Bridges, Structures Of All Types
Material Handling
Conveyors, Gantry, Overhead and Jib Cranes
Reninforced Concrete and Foundations
Industrial Piping and Ventilation
ECONOMY BANK BUILDING • AMBRIDGE, PENNA.

W. VANCE MIDDOUGH & ASSOCIATES
Consulting Electrical Engineers
Engineering • Design • Layout
Heavy Industrial Power & Light
204 Columbia Building .. Cleveland 15, Ohio
Prospect 1-2060

cFc co.
417 TERMINAL BUILDING
YOUNGSTOWN 3, OHIO
DESIGNERS OF
COMPLETE STEEL PLANTS

THE ENGINEERING MART
(CONTINUED)

CONSULTING ENGINEERS

E. C. NORWAY
ENGINEER
INGOT TO WIRE — PROCESS PLANT EQUIPMENT — STUDIES PLANS SPECIFICATIONS AND DETAIL CONTROL
116 East Lincolnway Valparaiso, Ind.
Phone 147

WARNER ENGINEERING CO.
Engineers
Consultation—Design—Detailing
Industrial Piping and Sewerage Systems
Industrial Waste and Sanitary Problems
411 Broadway Building Lorain, Ohio

PRODUCTS

Engineered-Rebuilding
of Your Machine Tools
SIMMONS MACHINE TOOL CORP.
Albany 1, New York
Pittsburgh Representative:
3541 Laketon Road PEnhurst 1-3700

POSITIONS VACANT

MECHANICAL DESIGN ENGINEERS

Positions available for Design Engineers with experience in the design of mechanical equipment used in Blast Furnaces, Open Hearth Furnaces, Sintering Plants, Rolling Mills and other auxiliary plants for the processing and production of iron and steel. These men must have experience in Steel Plant layout as well as the design of equipment involved. These are permanent positions with excellent advancement opportunities for qualified Engineers who are interested in greater accomplishment.

If you qualify and are interested in advancing with a continually expanding organization, write, giving complete resume of positions held and duties performed, education, age, salary desired, etc., to:

ARTHUR G. McKEE & COMPANY
2300 Chester Avenue
Cleveland 1, Ohio

USE THE ENGINEERING MART

POSITIONS WANTED

ELECTRICAL LINES WANTED!
Established manufacturers agent is desirous of representing an additional electrical equipment or supply firm in the Western Pennsylvania, West Virginia, and Eastern Ohio area. Box 101 IRON AND STEEL ENGINEER, 1010 Empire Building, Pittsburgh 22, Pa.

STEEL PLANT MANAGER
Wishes to re-locate. Twenty-three years experience. Rolling Mills, Bar, Structural, Pipe and Plate Mill. Experience in Open Hearth and all phases of steel plant maintenance. Managed steel plant in the east last four years. Box 102, IRON AND STEEL ENGINEER, 1010 Empire Bldg., Pittsburgh 22, Pa.

THE COST OF AN AD THIS SIZE IS $8.00 PER INSERTION

Book Reviews . . .

▲ **Radreifen, Radscheiben, Und Vollrader** (Tires, Hubs, and Solid Wheels) by O. H. Lehmann, 94 pages, 5 in. x 9 in., 55 illustrations, was recently published by "Stahleisen" Publishing Company, Düsseldorf, Germany. Book is written in German. This book deals with the production of wheels (solid as well as composite) for railroads. It begins with the ingot and ends with testing the finished product. Although Lehmann's book was written to describe the production of rolling material used by the German railroads, almost all of the described processes can be applied to American railroad wheels and tires. Several processes that were originated and developed in the United States are described and illustrated in detail. Some space is devoted to description and illustration of furnaces in which the ingots and blanks are heated. It is interesting to note that German continuous furnaces are successfully sidefired, whereas sidefiring is almost a heresy in the United States. The book contains many good line drawings and sectional drawings. Although almost all of the material contained in the book has previously been published in scientific and trade papers; the reviewer knows of no book in the English language that covers the subject under discussion. (Reviewed by W. Trinks).

men over 45

More than six times as many men of your age will die of lung cancer this year as died in 1933, according to official reports. Though our research scientists are making every effort to discover the reason for this increase, they still don't know the answer.

They *do* know, however, that the lives of over half of those who will develop lung cancer *can* be saved...if they get proper treatment while the disease is still in the silent stage, before any symptoms have appeared. That is why we urge you to have a chest X-ray every six months when you have your regular health check-up . . . no matter how well you may *feel*. Only an X-ray can detect the "silent shadow". It is your best insurance against death from lung cancer.

For more information about this or any form of cancer, call our nearest office or simply address your letter to "Cancer" in care of your local Post Office.

American Cancer Society

INDEX TO ADVERTISERS

FEBRUARY, 1953

A

Adalet Manufacturing Co. 180
Adams Co., Inc., R. P. 181
Aetna-Standard Engineering Co. 56, 57
Air Products, Inc. 163
Ajax Flexible Coupling Co. 170
Aldrich Pump Co., The 135
Alliance Machine Co. 142
American Air Filter Co. 38
American Brakeblok Division, American Brake Shoe Co. 134
American Bridge Division, United States Steel Corp. 181
American Chemical Paint Co. 158
American Manganese Steel Division, American Brake Shoe Co. 32
American Wheelabrator and Equipment Corp. 47

B

Bantam Bearings Division, The Torrington Co. 46
Birdsboro Steel Foundry and Machine Co. 19
Bliss Co., E. W. 13
Bonnot Co. 25
Brooks Oil Co. 45
Browning and Co., Inc., Victor R. 180

C

Cities Service Oil Co. 147
Clark Controller Co. 133
Cleveland Crane and Engineering Co., The 54
Cleveland Worm and Gear Co., The Cover 3
Columbia Electric Manufacturing Co. 183
Continental Foundry and Machine Co. 7
Crane Co. 22
Cunningham Co., M. E. 181
Curry and Co., Albert 139
Cutler-Hammer, Inc. Cover 2

D

De Laval Separator Co. 189
Documentation and Licenses, Paris, France 39, 40, 41, 42
Dowell, Inc. 136
Dravo Corp. 11
Drever Co. 127

E

Electric Controller and Manufacturing Co. 17, 44, 145, 159
Electric Furnace Co., The 18
Electric Service Manufacturing Co. 35
Electric Storage Battery Co., The 187
Elliott Co. 10, 169
Euclid Electric and Manufacturing Co., The 182

F

Falcon Bronze Co. 183
Farmers Engineering and Manufacturing Co. 188
Farrel-Birmingham Co., Inc. 193
Flinn and Dreffein Engineering Co. 39, 40, 41, 42
Foote Brothers Gear and Machine Corp. 8
Foxboro Co., The 149

G

General Electric Co. Cover 4
General Refractories Co. 26, 27
Gulf Oil Corp. 15

H

Halliden Machine Co., The 39, 40, 41, 42
Harnischfeger Corp. 206
Heppenstall Co. 123
Hyde Park Foundry and Machine Co. 148

I

Industrial Gear Manufacturing Co. 194

J

Johns-Manville Corp. 29, 174

K

Koppers Co., Inc. 20, 21, 24

L

Leeds and Northrup Co. 12
Link-Belt Co. 156
Lintern Corp., The 180
Lovejoy Flexible Coupling Co. 146
Lubriplate Division, Fiske Brothers Refining Co. 190

M

Manning, Maxwell and Moore, Inc., Shaw Box Crane and Hoist Division 155
Medart Co., The 144
Mesta Machine Co. 1
Metal and Thermit Corp. 210
Miles and Partner, John (London, Ltd.) 39, 40, 41, 42
Minneapolis-Honeywell Regulator Co. 52, 53
Mohr and Sons, John 151
Morgan Construction Co. 141
Morgan Engineering Co. 165

N

National Bearing Division, American Brake Shoe Co. 191
National Carbon Co., A Division of Union Carbide and Carbon Corp. 6, 160
National Roll and Foundry Co., The 2
Northern Engineering Works 129

O

Ohio Steel Foundry Co. Cover 1
Okonite Co., The 9

P

Pennsylvania Transformer Co. 51
Pittsburgh Lectromelt Furnace Corp. 60
Poole Foundry and Machine Co. 199
Post-Glover Electric Co. 150
Pyle-National Co., The 140

R

Reliance Electric and Engineering Co. 23
Rockbestos Products Corp. 121
Ross Carrier Co., The 157
Rowan Controller Co. 153
Rust Furnace Co. 119
Rust-Oleum Corp. 125

S

Spraying Systems Co. 183
Square D Co. 130
Stearns Magnetic, Inc. 198
Stoody Co. 179
Surface Combustion Corp. 48, 49

T

Taylor Chain Co., S. G. 192
Taylor Sons Co., The Charles 200
Texas Co., The 3
Timken Roller Bearing Co., The 58
Tool Steel Gear and Pinion Co. 43
Truflo Fan Co. 152

U

Union Carbide and Carbon Corp., National Carbon Co. 6, 160
United Engineering and Foundry Co. 173
United States Graphite Co., The 37

W

Wagner Electric Corp. 14
Wapakoneta Machine Co. 154
Waterbury Farrel Foundry and Machine Co. 28
Watson Construction Co., Grant 182
Wean Engineering Co., Inc., The 39, 40, 41, 42
Wean Engineering Co. of Canada, Ltd., The 39, 40, 41, 42
Wean Equipment Corp. 39, 40, 41, 42
Wellman Engineering Co., The 50
Westinghouse Electric Corp. 4, 5, 30, 31
Wilson Engineering Co., Inc., Lee 16

Y

Youngstown Alloy Casting Corp. 184
Youngstown Foundry and Machine Co. 205
Youngstown Welding and Engineering Co., The 197

THERMIT WELDING
Speeds PUNCH to Steam Hammer

Serious losses in production threatened a large mid-western forging company, due to long delays in obtaining forgings the size of a complete 35,000 lb. ram. It was, therefore, decided to manufacture the ram for a steam hammer by joining two smaller forgings with Thermit Welding (Fig. 1) . . . a job which took only two weeks. The fabricated ram has seen many months of severe service (Fig. 2), and based on its excellent record, others are being built in the same way.

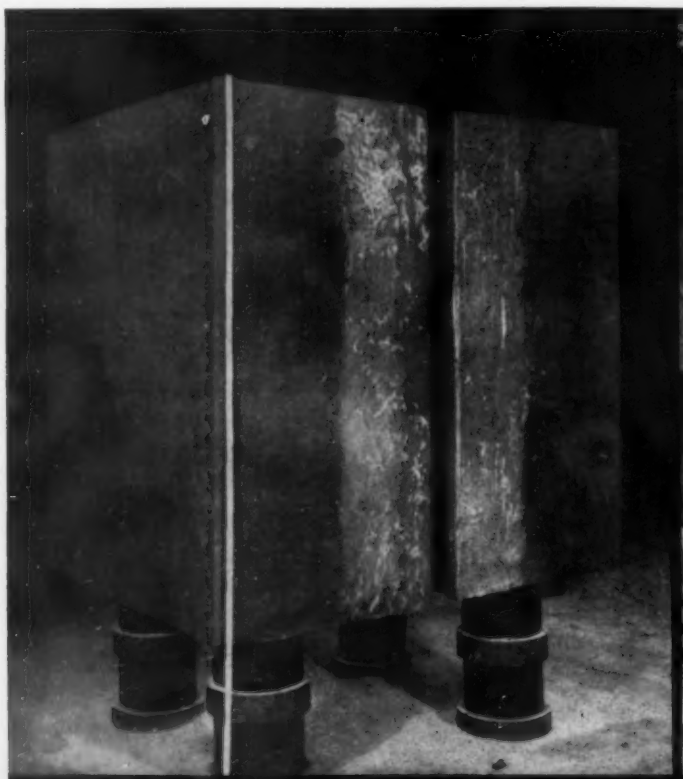


Fig. 1—Two forgings for ram in position prior to Thermit Welding.

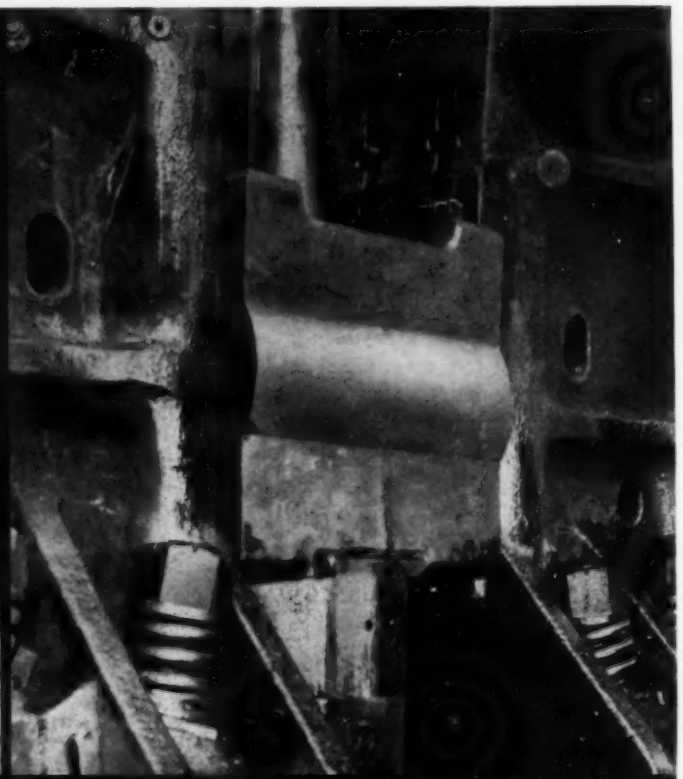


Fig. 2—Finished 35,000 lb. ram after fabrication by Thermit method.

CONSISTENTLY SOUND WELDS . . . MINIMUM OF TECHNICAL SKILL NEEDED . . . SPEEDY REPAIRS . . . LOWER THAN REPLACEMENT COSTS—four hard-hitting reasons for the swing to Thermit Welding in the repair, manufacture and maintenance of heavy drop forge industry equipment. Contact M&T on how Thermit Welding can help you!

THERMIT WELDING

METAL & THERMIT CORPORATION

100 EAST 42nd STREET • NEW YORK 17, N. Y.

NEWARK, N. J. • PITTSBURGH, PA. • E. CHICAGO, IND.
SO. SAN FRANCISCO, CAL. • PHILADELPHIA, PA. • TORONTO, CANADA

WORM GEARING—universal in its application—affords advantages for almost every power transmission job. Whether you want worm gearing sets or speed reducer units, you will find drives to meet your need in the complete Cleveland line.

Vickers Inc. hydraulic winch in operation on a Piasecki Hup-1 helicopter. Inset at left shows built-in Cleveland worm gearing.

Small Cleveland gearing speeds sea rescue

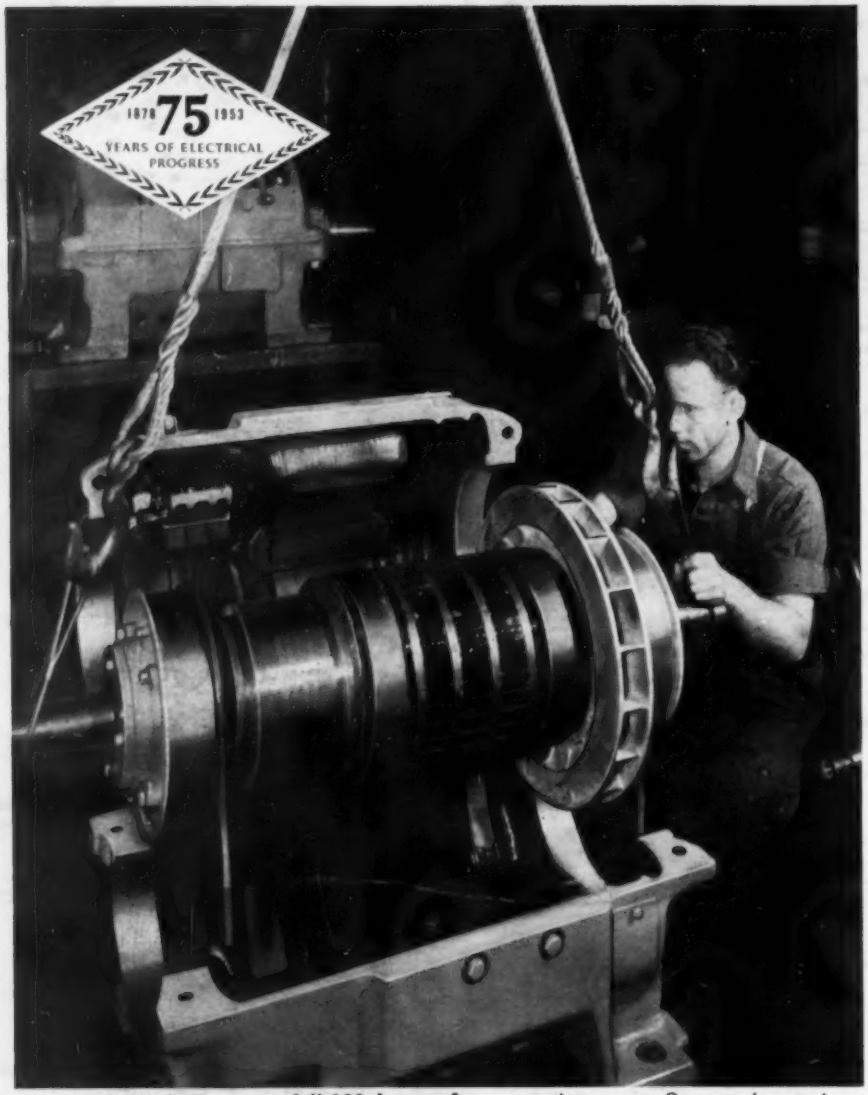
CLEVELAND worm gearing now has a part in a new kind of sea rescue. Just after the war, for the first time, a Vickers hydraulically-operated winch mounted on a helicopter hoisted two men to safety when an oil barge ran aground. Now use of the winch is standard practice, replacing hard-to-climb rope ladders previously used.

Vickers Inc. chose Cleveland worm gearing to drive the winch because it is small enough and light enough to satisfy rigid weight and bulk restrictions and is capable of governing efficiently sudden stops and starts and changes of direction involved in rescue work. To date Cleveland worm gearing has participated in over 1700 Korean missions.

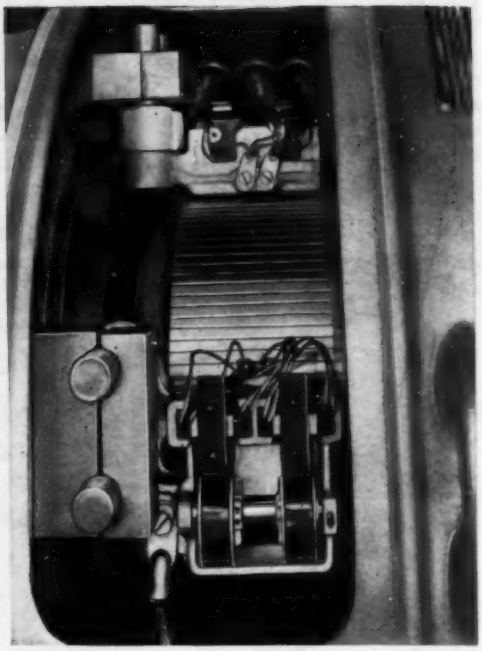
Cleveland manufactures worm gearing and worm gear speed reducers in a wide range of types and sizes, large and small, to meet the requirements of any machinery builder or user. Write today for Catalog 400. The Cleveland Worm and Gear Company, 3278 East 80th Street, Cleveland 4, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers, Limited.

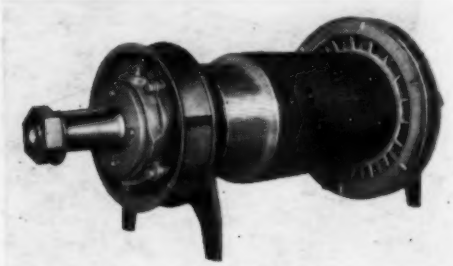
CLEVELAND
Worm Gear
Speed Reducers



HINGED TOP swings open to full 180 degrees for easy maintenance. On some larger sizes, top may be completely removed. Keys position frameheads in frame, which holds armature in place by clamping action. Thus, armature is released by opening frame.



WIDE COMMUTATOR OPENING gives easy access to entire brushholder assembly without necessity of opening frame.



MOUNTING FEET on armature frame head permit placing it directly on floor without supporting blocks, with no danger of rolling or damaging coils. Armature and commutator are assembled on a seamless steel sleeve, enabling shaft to be easily replaced without disturbing windings.

Motor built for fast, easy maintenance cuts steel-mill downtime

G-E mill motor features include long armature supporting feet, wide commutator opening, hinged top

Here's the heavy-duty mill motor—the General Electric MD-600—specifically designed to make maintenance easier, faster, and far less costly in terms of steel-mill downtime.

For example, armatures or field coils can be rapidly replaced without affecting motor-frame alignment; double-end drive shaft can be pressed out without disturbing commutator or windings; bearing cap and frame head are readily removed for disassembly and servicing of bearings; unique pressure-relief greasing system facilitates lubrication and keeps grease from entering commutator or windings.

These—and other convenience features illustrated above—are in addition to the rugged construction throughout that assures long motor life, and universal frame design that's adaptable to several types of enclosures. For complete information, contact your nearest G-E Apparatus Sales Office and ask for Bulletin GEA-4654, or write to General Electric Company, Section 659-86, Schenectady 5, N. Y.

GENERAL ELECTRIC